JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors, the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Commissions.—The perversion of the original meaning of the word commission, from authority or power to do something, to that of the reward or payment of a fee to the commissioner, is sufficient to indicate the departure from honest dealing, which has grown up with the delegation of the right to purchase in behalf of others. That a man's ability as a broker or trader or as a professional man, may properly be measured and remunerated by some definite amount, in proportion to the value of his *commission* (in the correct and original meaning of the word) is unquestionable; and a customary, or agreed upon, poundage or percentage is one of the admitted conditions of commerce and of art; but the *private* receipt or payment of such poundage or percentage, however frequently or generally accepted, will not be *justified* by custom, as it is unwarranted by agreement of the person, company or governmental body, that incurs the expenditure.

Still it is well known that the habit exists. The increase of larger manufacturing establishments; the aggregation of capital in manufacturing and railway companies, the expenditures of cities and towns for public improvements, and of government for the same, in time of peace, and of the latter for warlike purposes, in time of war or threatening; all require the large outlay of money, generally to be entrusted to officials, under salaries for the very purpose of making the outlay; the making of such outlay being rarely, in this country at least, under the direction of brokers or professional men, with understood rates in lieu of stipends. The demand on the receipt of a *commission* under these circumstances becomes an act of dishonesty, and its payment by the merchant, tradesman, manufacturer, engineer or builder, a participation in the wrong; while the whole community *may* be arraigned for connivance in the frauds.

This condition of things is not peculiar to this country alone. One of the last numbers of the *Builder* (London) contains a statement that at a meeting of the Institute of Architects, a circular or advertising pamphlet was distributed, relating to some of the requirements of house building, in which was placed a separate notice that a commission would be allowed to architects recommending or procuring the use of the article advertised. Attention was called to the fact, and it was animadverted upon without stint or apology; but the existence of such a proposition, the reluctance to expose the name of the person making it (with an evident compassion for his ignorance, rather than an indignation at his criminality), and the neglect to pursue the subject beyond a disclaimance, leaves a grave suspicion that there may have been instances of acceptance of, and possibly of demand for, commissions, by clerks of works, if not by architects.

It is not too much to assert that both here and in England (supposing that courtesy will permit us to assert ourselves first in the order of demerit) there is a popular belief that money is made in this way by higher professional men, as well as by subordinates. It is hard to perceive how some men can live otherwise, and harder yet to comprehend how some work or material is recommended or passed except by some direct interest in the sale or in the final acceptance. The evil permeates all official and business relations, reaching to the limit of all trust or employment. It would be easy here to descant upon the relation of the unpaid or underpaid members of any mu-

nicipal, state, or of the general government, to elected or appointed officials, or the the work to be performed under the direction of such officers; or to dilate upon the opportunities for profit, of unpaid directors in companies through employees, or in whatever other ways personal emolument can be attained; but it is sufficient to restrict the present remarks to the proper relationship of advising and purchasing agents to manufacturers and dealers, in regard to *compensations*.

As a matter of pure business, it is at once admitted that a judicious purchase is of great advantage to any buyer, and that the ability, knowledge or intelligence, which enables one man to effect such a purchase better than another, is a valuable commodity to be paid for. It has come, or is coming to be recognized, that the lowest bidder method of purchase, inevitably fails to secure a satisfactory bargain. The keen purchaser who attempts to get more for a dollar than a dollar's worth, is frequently, and always in the end, outwitted—the covenants to perform become the less effectual as they are made the more binding—the more cunning the stipulation, the more knavish the contractor;—and sooner or later, such a buyer finds that he had better have made his purchase in open market, from those who would have gained a profit from the sale and have had a stake in the perpetuation of their trade or manufacture.

On the other hand the seller finds it for his interest to push his wares, and in so doing he can or will concede a brokerage, consoling himself with the idea that such a "commission" is not illegal or immoral. In this view he is unquestionably justifiable—with a qualification—that the transaction must not be a private one. The seller, however, has no right to pay for the procurement of an order, or for the acceptance of material or work, any sum of money, which will not be publicly acknowledged and openly paid. Such a payment can only be a bribe to the recipient, and a theft from the principal in the purchase.

As to the engineer or architect, the purchasing agent of whatever degree, the demand for an acceptance of such private fees cannot be characterized by too strong language, or condemned in too open a manner. If professional advisers will take the most decided stand upon these points and make public every offer for *commissions* they may receive, there will ensue a restoration of popular opinion in their behalf, and, sooner or later, a higher appreciation of the value of technical direction and advice will result.

Circular Ironclads.—The many good qualities developed on the trial trip of the circular ironclad Novgorod, designed for the Russian navy by Admiral Popoff, has brought forward several claimants for the honor of having first suggested this form of war vessel, and an animated controversy has resulted, and much light has been thrown on the efforts of others in this direction.

It is claimed that Mr. Geo. Herbert, in 1854, made designs for circular ironclad forts, provided with propelling power, which were laid before the authorities in England as early as 1855; that Mr. Geo. Rennie read a paper at the meeting of the British Association in 1858 on the "construction of fixed and floating batteries for coast defense," and exhibited models of circular ironclads.

Sir Samuel Baker claims to have submitted to the admiralty as early as 1866, plans for circular ironclads; and the firm of John Elder & Co., Glasgow, claim that the late Mr. John Elder, in May, 1868, read a paper before the Royal United Service Institution, entitled, "circular ships of war with immersed motive power," in which he advocated the building of circular ironclads, and claimed for his designs both high speed and steadiness at sea. The friends of Mr. Elder are very emphatic in the support of his claims, and hold in substance that the "Popoffkas" being circular ironclads, they cannot allow it to be understood that Admiral Popoff is the inventor; and further that in the autumn of 1868, Admiral Popoff spent some time in Glasgow, and during the greater part of two days, Mr. Elder explained to him his plans for circular ironclads.

In opposition to these statements we have that of Admiral Popoff, that he "never heard from him (Elder) anything about his spherical ship, which, in the only form in which I understood it, was impracticable, involving great draught of water and great expense," and adds, "it is my duty to say that my ship is not in any degree derived from his spherical vessel."

A comparison of the two plans shows that of Mr. Elder to have been a "small segment of a sphere," while on the other hand, in that of Admiral Popoff, the immersed portion is almost cylindrical, the bottom being flat and nearly as large as the section at the water line.

It is this radical difference in design, although both are circular in horizontal section, which enables the latter to carry a much heavier armor in small draught of water, and to be built at moderate cost.

He attributes the origin of his ironclad to having been taught many years ago by Mr. E. J. Reed, C.B., that by shortening the ship the

extent of surface to be protected by armor is diminished, and by increasing the breadth the displacement is increased, and consequently the ability to carry the armor is also increased. K.

Ile's Differential Compass.—At the meeting of the Institute in December last a model of the working parts of this instrument was exhibited and explained. This compass is intended to show on shipboard any aberration of the steering needle caused by iron, either as used in the construction of the vessel or carried as cargo, and to enable a mariner to restore true reading by making due compensation.

Its principal difference from the ordinary ship's compass consists in its having two needles suspended in the usual way and placed one above the other at such distances as to preclude undue mutual influences. These needles are constructed of strips of non-magnetic material—preferably alluminum—6 in. long by $\frac{3}{4}$ in. wide. On the upper one are fastened a large number of minute steel magnets, about $\frac{3}{4}$ in. long, placed parallel with the body of the needle and the like poles all in one direction. As each magnet tends North and South, the whole needle will point in that direction.

The lower needle is composed of a strip and magnets of the same materials and dimensions, but the magnets are fastened to the strip crosswise with the like poles all in one direction, and as all these magnets tend North and South, this needle will point East and West. The needles are thus constructed in order to distribute the magnetic force evenly through their length and thus cause them to be equally influenced in aberration and compensation.

It is evident that if there be no local attraction, the two needles must stand at right angles to each other, but when such local attraction does exist, it will be detected by the inclination of the needles toward it at an acute angle; the amount of deflection of each needle depending on the position and strength of the local attraction.

Compensation to restore true reading is effected by using the repellant pole of a large bar magnet in either acute angle until 90° is restored. But as the compensator can restore 90° when placed on any line, and as it only gives true results when its direction coincides with the direction of the disturbing cause, the latter is determined by using the bar magnet in connection with a short table to be constructed at the factory and to accompany each compass. When the position of the bar magnet for obtaining true compensation has been determined, it is fixed there until there is a marked change in the ship's heading, when it will need to be determined anew.

The American Society of Engineers and the Centennial Exhibition.—It having been determined by this Society to make an exposition of the progress of engineering at the approaching Exhibition, a committee of members was delegated, with authority for this purpose. This committee, consisting of Messrs. Theo. E. Ellis, chairman, J. James R. Croes, Robt. Briggs, Octave Chanute, Alex. L. Holley, W. Sooy Smith, and William P. Shinn, have divided the labors into several heads, embracing all the branches of the profession. These several sub committees have issued circulars asking the assistance of all persons who can supply it in their respective ways; the following from Sub-Committee XI will speak for itself. Any reader of this article will please consider the communication addressed to himself:

"SIR:—The Commission, under whose direction the American Society of Civil Engineers has placed the exposition of the growth, progress and present condition of Engineering in America, at the approaching Centennial Exposition in Philadelphia, has delegated to this Sub-Committee (undersigned), the charge and arrangement of that portion of the Exhibition which relates to Steam Engineering.

This exhibition on the part of the Society is not supposed to trench upon the mechanical department of engines, boilers or models in the Hall, but to supplement and illustrate that department in its general relation to civil engineering, both historically and practically. The application of steam in internal navigation of rivers and canals, in ocean navigation, in locomotion, in construction, dredging, excavating, hoisting, water works and mines; the origin, steps of progress and final point of development of all these, afford great scope for illustration by models, copies of old or new drawings, and by descriptions. Already the possibility of recording much that has been done in steam engineering has passed away. Much, if not most, of the practice of the engineer in the work shop, in use to-day, has never been recorded at all, and above all, its origin has never been asserted or declared; the opportunity at this time given to perpetuate the memory of invention and of skill, must now be accepted or the history be lost. Above all, the isolated practice and individual development of the directing engineer are generally left unnoticed and undescribed. For the collection of this kind of information, and its presentation at the Centennial Exhibition in suitable manner, the Centennial Commission has placed at the disposal of the American Socie-

ty of Civil Engineers, a large room in the Main Building, of desirable location and ready access, and the Committee confidently appeals to engineers to supply the requisite material.

Upon these grounds the Sub-Committee on Steam Machinery asks you to furnish such plans, models, or descriptions as you may have or be willing to prepare.

It is especially desirable to have models of old engines, locomotives, or boilers or machinery, now superseded or improved, and it is recommended to supply photo-lithographs of drawings or tracings. It would be well to make or have made the photo-lithographs to a uniform size of sheet not over 12 x 10, with a scale drawn on each sheet.

The Sub-Committee would also ask you to communicate this request to any persons who may to your knowledge possess any engineering information desired by the Committee, and solicit their contributions.

We want descriptions and illustrations of engines, boilers and work long since gone out of use, of those in use to-day, and of those prospectively valuable. The descriptions should be concise, the statements confined to points of verification, and without allusions to rivals in former or present existence. The purpose of our exposition is to furnish to foreign and American civil engineers, historical and practical information regarding steam engineering.

For the convenience of readers, it is requested that descriptions or writings be made on legal cap or cut foolscap paper, using one side only to write upon.

Any members of the Society, or other gentlemen (to whom they shall give this circular, or from whom they may solicit contributions) are requested to communicate with the Chairman of the Sub-Committee, stating what can be contributed *or obtained*, together with memoranda of space wished for, and such other information as will ensure the proper use of material and the best place to exhibit it in.

It will confer a great favor if you will give a written answer to this letter at the earliest moment, if anything occurs to you, or if you yourself can do anything to advance the purpose of this Committee, as set forth above. Respectfully yours,

ROBERT BRIGGS,
Chairman Sub-Committee XI.

Address,
Room 2, Franklin Institute Building, No. 15 South 7th Street, Philadelphia, Pa.

Correspondence.

To the Editor of the JOURNAL OF THE FRANKLIN INSTITUTE.

DEAR SIR:—In the February number of the Journal, an article on "Safety Boilers" is so worded as to lead the reader to draw an unfavorable conclusion with regard to all boilers constructed of cast iron.

The Harrison Boiler is composed wholly of the material in question, except the bolts required to hold the parts together, and we claim that perfect safety from destructive explosions, has been attained by its mode of construction, notwithstanding the fact, that the castings are exposed to the direct action of the fire.

In the article referred to, you say, "there is a possibility of attaining a *measure of safety* in the construction of boilers in small and multiplied parts." We would substitute the words *perfect safety from destructive explosions*, for measure of safety; and add that the small and multiplied parts. if of cost iron, should be, to use Mr. Harrison's own words, "of such a form as will prevent harm in case of rupture.

In answer to your objection to the use of cast iron where exposed to the fire, we would again quote Mr. Harrison's words: "Cast iron expands less at the same temperature than wrought iron, and this difference might seem likely to interfere with the tightness of the joints in the Harrison Boiler. But with the compensating curved lines of the units, and a due proportion being maintained between the bolts and the spheres, no trouble need arise from irregular expansion."

We claim, and experience has proved us correct, that by the form used for the sections of the Harrison Boiler, considerable elasticity has been secured, thereby preventing the difficulties suggested by you, and which certainly have to be guarded against in the construction of a cast iron boiler.

The best proof that it is both possible and practicable to make a boiler of cast iron, and attain safety, is the fact that, after a test of thirteen (13) years, of the great number of Harrison Boilers that have been made and are in use, there has not been a single case of destructive explosion.

In the JOURNAL OF THE INSTITUTE for February, 1867, will be found a report of the Committee on Science and the Arts, of a series of experiments, and tests of the most severe character; this report contains the following words: "The Committee are impressed with the great utility of the boiler, as one perfectly safe and free from all danger of explosion even when carelessly used. And the report closes with these words, "with the known advantages of the use of cast iron, and the unlimited scope in the arrangement of heat absorbing surface, coupled with the demonstrated fact of *safety*, your committee unhesitatingly approve, and heartily recommend it to public favor." Signed, Coleman Sellers, Chairman, John Agnew, J. F. Frazer, Henry Morton, J. C. Cresson.

In 1871 the Rumford Medal was awarded by the American Academy of Arts and Sciences, to Jos. Harrison Jr., "for his method of constructing Steam Boilers, by which *great safety* has been secured." This honor was entirely unsolicited by Mr. Harrison, and is additional proof that the safety of the boiler had become an acknowledged and undisputed fact. Yours, Respectfully,

HARRISON BOILER WORKS,

Philadelphia, Feb. 18th, 1876. per Lewis Sylvester.

The Metric System of Measures and Weights.—At the November meeting of the Boston Society of Civil Engineers, a report was made by the committee appointed to consider the introduction of the metric system and what action the society ought to take respecting it, and the following resolves and orders were adopted:

Resolved, That it is very desirable that the metric system of weights and measures should be generally adopted, and the irregular standards now in common use abandoned.

That the committee on the metric system be hereafter a standing committee.

That the standing committee prepare a memorial to the Congress of the United States on behalf of this society, praying that honorable body to enact that after some fixed date, the metric standards in the office of weights and measures at Washington should be the sole authorized public standards.

That approximate weights and measures be procured for the society rooms.

That the State Board of Education and the Boston School Committee be addressed, urging that the instruction be made more thorough by putting the real weights and measures into the hands of the pupils.

That the committee be instructed to communicate to the U. S. Commission for testing iron and steel, a request on behalf of this society, that their report may be made in terms of the metric as well as the more common standards.

That the committee be authorized to open correspondence with other societies with a view to securing united action in petitioning Congress.

That the secretary be instructed to publish what action the society has taken in this matter, in the principal newspapers and professional periodicals.

Improvement in process of melting iron in cupolas.*—At the Edgar Thompson steel works (Bessemer), at Pittsburgh, the difficulty which frequently occurs in the cupola for melting iron in continuous use, of a scaffold (or obstruction of metal and coke in form of a mass or shelf adhering to the sides of the cupola), presented itself; and the Superintendent of the works, Mr. Wm. Jones, conceived the idea of effecting the removal by the use of pulverized fuel, injected with the blast, at the tuyeres through which the air was usually forced. Upon placing a quantity of small coal in the tuyere pipes, and putting on the blast, the result was immediately successful, in the removal of the entire scaffold, and the cupola afterwards continued in work as usual. A further consideration led to the conclusion that scaffolding might be altogether prevented by a continuance of the process, and an arrangement has now been effected, whereby a portion of fine coal is infused into the blast at all times; which process has not only prevented the formation of scaffolds since, but has melted the iron so much better and more rapidly, that only one cupola is used at this time, where two were necessary before the pulverized fuel was introduced.

But this is not the only or most important advantage secured by this discovery. It is well known to the iron founder that the great waste of iron in melting in a cupola, occurs from the exposure of a mass of white-hot, or melted iron, where little or no fuel is present, to a current of air, in which the iron itself burns freely. By supplying a portion of carbon with this air, not only the requisite heat for melting the iron will be furnished, but the iron itself will be protected from oxidation. The tuyeres of the cupola at the Edgar Thompson steel works, when using the pulverized fuel, are as bright as those of a blast furnace at a temperature of 1000° Fah., and the walls of the lining are glazed.

This improvement is found not only to save the waste of iron, but to transmit to the converter a much larger proportion of the carbon originally in the pig,—a very important consideration. In conclusion, this improvement is not limited to the Bessemer process, but would be of great value to all cupolas melting iron for castings of any character, as well for the light castings of the stove moulder, where it will preserve the fluidity of the metal, and softness of the plates; and

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* Extracted from *Am. Manufacturer and Iron World*, Pittsburgh, Feb. 24th, 1876.

also for the machinery founder, where the uniformity of character from long or heavy heats is especially desirable; and it is possible that the principle may be extended to the blast furnace itself.

The Iron Industry.—The American Iron and Steel Association has just published a revised directory of furnaces, rolling mills, steel works, forges and bloomeries in every State of the Union. This is an exceedingly valuable pamphlet of 136 pages. The following summary of the number and capacity of the furnaces and rolling mills in the United States is given:

	Tons of 2240 lbs.
Whole number of completed blast furnaces January 1, 1876,	713.
Annual capacity of all the furnaces,	4,856,810 tons.
Whole number of rolling mills January 1, 1876,	332.
Whole number of single puddling furnaces (each double furnace counting as two single ones),	4,475
Total annual capacity of all rolling mills in finished iron,	3,740,860 tons.
Annual capacity of all the rail mills in heavy rails,	1,732,410 tons.
Number of Bessemer steel works January 1, 1876,	11.
Annual capacity in ingots,	450,000 tons.
Number of Bessemer converters,	24.
Number of open-hearth steel works January 1, 1876,	16.
Number of open hearth furnaces,	22.
Annual capacity in ingots,	41,000 tons.
Number of crucible and other steel works January 1, 1876,	39.
Annual capacity of merchantable steel,	97,550 tons.
Of which there are of crucible steel,	41,000 "
Number of catalan forges making blooms direct from the ores January 1, 1876,	39.
Annual capacity of blooms and billets,	53,080 tons.
Number of bloomeries January 1, 1876, making blooms from pig iron,	59.
Annual capacity in blooms,	53,750 tons.

Franklin Institute.

HALL OF THE INSTITUTE, Feb. 16, 1876.

The stated meeting was called to order at 8 o'clock, P. M., Vice-President Chas. S. Close, in the chair.

There were present 108 members and 7 visitors.

The minutes of the last meeting, held Jan'y 19th, were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting the following donations were made to the library:

Annual Reports upon the Preservationof the Falls of St. Anthony, Construction of Lock and Dam at Meeker's Island, Minnesota, and Improvement of Minnesota River, in charge of F. W. Farquhar, Major of Engineers, etc., being Appendix H of the Annual Report of the Chief of Engineers for 1874. Washington, 1874; also Appendix J of the Annual Report of the Chief of Engineers for 1875. Washington, 1875. From Gen. A. A. Humphreys, Chief of Engineers.

Report on the Compressive Strength, Specific Gravity, also Ratio of absorption of the building stones in the United States, by Q. A. Gilmore. New York, 1876. From D. Van Nostrand, Publisher.

Papers relating to the foreign relations of the United States, transmitted to Congress with the Annual Message of the President, December 6, 1875, preceded by a list of papers and followed by an Index of Persons and Subjects; 2 vols. Washington, 1875. From the Dept. of State.

Laws and regulations of the American Philosophical Society, held at Philadelphia, for promoting useful knowledge, as finally amended and adopted Dec. 16, 1859. Together with the Charter of the Society and a list of its presidents. Philadelphia, 1875. From the Society.

Eighty-seventh Annual Report of the Regents of the University. Transmitted to the Legislature, February 18, 1874. Albany, 1874.

Fifty-seventh Annual Report of the Trustees of the New York State Library for the year 1874. Transmitted to the Legislature, Feb'y 5, 1875. Albany, 1875.

Twenty-sixth Annual Report on the New York State Museum of Natural History, by the Regents of the University of the State of

New York. Transmitted to the Legislature May 2, 1873. Albany, 1874. From the Board of Regents, University, N. Y.

The Actuary further reported that there were two vacancies in the Board, one arising from the election of Mr. J. E. Mitchell as vice-president, and the other from a tie vote at the annual election.

The Actuary also presented the report of the Board on the preamble and resolution relating to the increased usefulness of the Institute, referred to the Board at the December meeting, which report was adopted.

The report contained the following suggestions:

1st. To ask of *each member* of the Institute his *individual* exertions to add to the roll of membership.

2d. For the members of the Institute to give their support and encouragement to the committee on instruction by evincing more interest in the lectures given in the Institute.

3d. To encourage minors and apprentices to *make use* of the facilities for instruction afforded by the Institute, under the privilege of membership. Your committee would recommend extending the use of the library and reading room to apprentices on payment of one dollar yearly for each.

4th. That the drawing school be enlarged so as to accommodate *all* applicants.

5th. That in addition to the usual course of lectures, a second course be instituted, intended particularly for apprentices, and those who have not enjoyed the advantages of a generous education. Said second course of lectures to consist of *elementary instruction* in mechanics, pneumatics, hydrostatics, hydraulics, optics, chemistry, etc. This course of lectures to be free to all on payment of a nominal fee for admission.

6th. That a small pamphlet be published for distribution, being a guide for apprentices and young students to approved text books on the various sciences and industrial arts.

7th. That at the monthly meetings of the Institute—in addition to the exhibition of novelties, and the reading of papers—we invite observations derived from the *practical every day work* of the mechanic, artisan and scientist. Simple as some of these observations may appear, they often open up by discussion a mine of information to those not practically versed on the subject.

Mr. J. J. Weaver presented the following, which was adopted:

Resolved, That the report of the Board of Managers touching the increased usefulness of the Institute, as presented and adopted this

evening, be printed and sent to the members with the notices for the next monthly meeting.

Mr. Emil Geyelin read a paper on the "Comparative value of turbine wheels under part gate," which was illustrated by diagrams and pictures projected on the screen. Mr. Robert Briggs followed with some remarks on the construction of turbine wheels.

The Secretary presented some specimens of vulcanized fiber, to be used as packing for steam joints, and as an antifriction material in the wearing parts of machinery.

The Secretary presented a communication from the Boston Society of Civil Engineers, asking the co-operation of the Institute in petitioning Congress to fix a date after which the metric system of weights and measures, shall be the only legal standard.

On motion of Mr. W. P. Tatham the communication was referred to a committee of three for a report.

The Chair appointed as such committee, Messrs. W. P. Tatham, Coleman Sellers and Robt. Briggs.

Mr. H. W. Bartol called attention to the two vacancies in the Board of Managers, as reported by the Actuary, and nominated Messrs. Richard McCambridge and Mr. C. H. Banes, they having received the highest number of votes at the annual election, except Mr. Adamson, who had declined.

The following members were also nominated; Dr. C. M. Cresson, H. G. Morris, T. Morris Perot, Robt. Briggs.

On motion, it was resolved that the meeting do now proceed to an election of one member of the Board to fill the vacancy caused by a tie vote at the annual election, and another to fill the vacancy caused by the election of Mr. J. E. Mitchell as Vice-President, and that the one receiving the highest number of votes be considered as elected for the longer term; and the one receiving the next highest for the shorter term.

The Chair appointed Messrs. Hector Orr, C. Chabot, and J. W. Nystrom as tellers; after all had voted who wished, the tellers reported that Mr. Briggs had received the highest, and Mr. McCambridge the second highest number of votes, whereupon the Chair announced that Robt. Briggs was elected a member of the Board of Managers to serve two years and eleven months, and Richard McCambridge to serve eleven months.

The following letter from Mr. B. H. Moore was read:

Philada., February 1st, 1876.

To the President and Members of the Franklin Institute:

GENTLEMEN:—Permit me to tender to you my resignation as one of the Vice-Presidents of the Institute.

Very truly yours, B. H. MOORE.

Mr. Bullock remarked that he regretted to learn of the contemplated resignation of Mr. Moore. For many years Mr. Moore has been very active in the interests of the Institute, especially in the committees of which he was a member. We cannot afford at the present time to lose the value of his long experience. Should his resignation be accepted, he will be no longer a member of the Board of Managers. The following resolution was offered and *unanimously* adopted:

Resolved, That the consideration of Mr. Moore's resignation as Vice-President of the Institute, lie over until the next meeting, in hope that Mr. Moore will be induced to reconsider said resignation.

Mr. Orr announced the death of Prof. John C. Cresson, with some remarks on his long connection with and great service to the Institute, and offered the following preamble and resolutions, which were unanimously adopted.

WHEREAS, Since our last stated meeting we have to report the death of Professor John C. Cresson, a member of the Franklin Institute for forty-two years, and during the most of that period active as a manager; for nine years its president, and for a quarter of a century, chairman of its committees on science and the arts; therefore,

Resolved, That we hereby acknowledge by his death our loss in the various relations which he has borne among us, whose duties he discharged with faithfulness, constancy and rare suavity, even under declining health, and now that he has answered the stern summons which await us all, and in view of the close of this long service, we feel that we may not soon look upon his like again.

Resolved, further, That these proceedings be entered in full upon our minutes, and a copy of them be presented to the family of Mr. Cresson.

Mr. J. E. Mitchell, one of a committee appointed by the Board of Managers upon securing room at the Centennial Exhibition, stated that they had secured a very eligible room in the northwest portion of Machinery Hall, and have been authorized by the Board to furnish it for an office and reception room of the Franklin Institute.

On motion, the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

Bibliographical Notices.

THE ELEMENTS OF PHYSICAL GEOGRAPHY, for the use of Schools, Academies and Colleges.—By Edwin J. Houston, A. M., Professor, etc., in the Central High School of Phila. Eldredge & Brother, Philadelphia, 1875. Price, $1.75.

This epitome of Physical Geography is intended as the elementary book for school children, having been condensed to include merely the necessary groundwork of the study, while at the same time it has been made to be comprehensive of all the principal facts. Great care has been taken to secure strict accuracy of statement, with such explanations as shall make clear to the mind of the student the relation of the physical conditions to themselves, and to the results of observation. Besides being well compiled and edited, the book is admirably printed, in quarto form, with clear type, upon good paper, and serviceably bound; and from comparison with similar text books, it appears to present itself to much favor with teachers and to the community.

BURLEY'S UNITED STATES CENTENNIAL GAZETTEER AND GUIDE.—S. W. Burley, Philadelphia. By Charles Holland Kidder, Editor, 1876. Price, $2.00.

This combination of the history, geography, compendium of the last census, compilation of the constitution, and other information relative to the United States; together with a Guide to the U. S. Centennial Exhibition, and cognate matter, accompanied with numerous advertisements of the greatest value to the parties advertising, is really a well collated mass of somewhat desultory information, carefully edited and neatly published. The book would be somewhat improved if the reading matter had as good an index as the advertisements; and second and succeeding editions being promised, perhaps this addition will be deemed advisable, as an inducement to the purchasers of the first, to secure the following editions. The work will undoubtedly have a large circulation.

THE ECONOMY OF WORKSHOP MANIPULATION.—By J. Richards. E. & F. N. Spon, London and New York, 1876.

The contents of this work have mainly been published in the JOURNAL OF THE FRANKLIN INSTITUTE, having originally appeared on its pages. The separate papers as they came out, were copied into the leading scientific journals, and educed much approbation for their practical, instructive character. The whole has been collected and reprinted in 16mo. form, suitable for the library or the student.

Without entering into any review of a book whose contents are so well known to the readers of the JOURNAL, it is sufficient to notice the fact that it can be bought as a whole, and to recommend the purchase.

Civil and Mechanical Engineering.

STEAM BRICK KILN.

By Henry W. Adams, M. D.

(Abstract from a paper read before the Franklin Institute at the meeting, Jan. 19, '76.)

The object of this paper is to describe a new and improved process of burning a kiln of bricks, uniformly hard, without a salmon brick, or a blackened, or a glazed brick in the kiln, and in one-half the time, and with one-half the cost for fuel now required.

Bricks may be made by any of the known processes, but they are then only pieces of mud, and are not, in this condition, merchantable. They must be burned in order to be of any value. The comparative value of a brick made from our beautiful clay, depends upon its hardness and the brightness of its deep red color. To develop these qualities a high, sustained, and uniformly distributed heat is necessary. Such a heat cannot be secured in the old kilns. The outside walls absorb a large portion of heat and thus rob the bricks next to them, of the heat necessary to burn them hard. The heat, ascending from the fires, passes freely, from the top of the kiln into the air, and is largely wasted. Hence, more fuel is used to burn an old kiln than is needed, if it could be properly distributed and utilized. When the fires are first fed with coal the gases generated fill the top of the kiln more abundantly and raise the temperature of the bricks; soon the coal cokes, and the production of incandescent gases, rising through the kiln, is diminished. The superincumbent air, now no longer lifted from the top of the kiln, by the ascending gases, settles down upon, and insinuates itself between the top courses of the kiln, and cools them. Thus the top and sides of an old brick kiln produce a large quantity of salmon bricks. These bricks are worth in this market about seven dollars per thousand. They average about one-fourth part of the kiln. It costs just as

much to dig the clay, to temper it, to mould and dry these bricks, and set, and burn and handle them, as it does to make hard stretchers and paving bricks, which are worth from sixteen to twenty dollars per thousand. Besides in an old kiln, only a small number of pressed bricks can be properly burned in the heart of the kiln. The arches, from necessity, are always overburned in consequence of prolonging the firing sufficiently to burn the top and sides of the kiln into respectable salmon. This is a fair statement of the case. The practice and skill of generations have failed to remedy these defects.

To burn any kiln of bricks uniformly hard, and of a deep red color, three things, at least, are necessary :

1. The necessary quantity and degree of heat must be made.

2. This heat must be equally distributed to and surround every brick in the kiln for the same length of time.

3. This heat must be held in the kiln, under a pressure greater than the outside air, so as to cause it to fill the entire honeycomb of the kiln, and wrap every brick, and burn the top and sides as quickly as the bottom.

If these conditions can be realized in a kiln, it is easy to see that a uniform result will be obtained. But, to do this, it is necessary that the kiln should be an oven. The heat must be made outside of the kiln proper, and driven into, and under it, by forcible jets of steam, in order to fill the kiln with the necessary heat, under pressure. The top must be banked down by at least two platting courses of burned bricks to hold in the heat. In an old kiln the draft is shut off by closing up the top so tightly ; but in the new kiln, it is practicable to do so, because no dependence is placed on the natural draft.

For three or four hundred dollars an old brick kiln can be converted into one suited to the new process. Take for example a ten arch kiln, built in the old style. To alter this, take out the grate bars and widen the ash pits to the width of two feet, and turn an arch over each, composed of fire bricks, and filled with pigeon holes about two inches square, to let the heat through under the whole bottom of the kiln. The floor of the kiln is leveled off, and the bricks to be burned are set directly on this floor, without arches. The kiln is set in the usual manner, and two platting courses of burned bricks are laid down on the top platting course of green bricks. They are left loose enough to let the water smoke escape, then tightened down

when it has gone. The fire places are built in front of the old fire doors, on the outside of the kiln, and the grates in these furnaces are four feet long, and two feet wide, and are on a level with the old ash pits, so that the products of combustion are driven into the permanent and pigeon holed arches, under the bottom of the kiln. Jets of steam, escaping from nozzles, three-sixteenths of an inch in diameter, are let into the furnaces, over the fire doors, under a pressure of about sixty five pounds to the inch, sweeping over and across the burning fuel. They make a partial vacuum in the furnace next to the fire doors, and draw up large volumes of air to intensify the combustion. No smoke is left unconsumed. The white hot gases, and superheated steam are forced under the whole bottom of the kiln and made to pass up through the pigeon holed arches, and thence through the bottom of the kiln, and fill the interstitial spaces between the bricks.

The top platting courses being now closed up tight, the kiln becomes an oven, filled in every part with a uniform heat. A partition is placed in the middle of the length of each arch to prevent the two opposite blasts from acting against each other. The steam is superheated at the expense of the overheated arches and bottom of the kiln, and becomes a carrier to lift up the heat and circulate it through the upper parts of the kiln. To cheapen the cost for fuel and to produce a large volume of flame to help forward the process of burning and coloring the bricks, I surround my kiln with a half inch pipe, from which branches, one-fourth of an inch in diameter, lead and look over an inch hole through the top of each furnace, to allow a small stream of crude petroleum, about as large as a needle, to fall down on to the red hot coals and burst into flame. The jet of steam shooting over the fire door and through the furnace, draws in air and produces the most intense combustion, and supplies the entire bottom of the kiln with an abundance of heat of the highest and most uniform intensity. This great source of flame and gases enables the use of cheaper fuel and the substitution of fine instead of ordinary coal. The grates are plates of cast iron, four feet long, and two feet wide, perforated with small round holes, about three-eighths of an inch in diameter, on the upper side, and half an inch wide on the under side, to let the ashes fall through without clogging. The fires are kindled with wood and large coal at first, and then the fine coal is gradually thrown on, and kept about a foot thick. The small

stream of petroleum falling on to this red hot bed bursts into flame, and the forcible jets of steam draw in the air for perfect combustion, and nothing can exceed the economy, regularity, and perfection of the heat thus produced.

It is this perfect regularity, and continuity of the heat produced by the furnaces, which render the burning of the kiln so easy and so perfect. There is no danger from the use of petroleum in this manner. Explosions can never take place with any hydro-carbon, without an admixture with its vapor of atmospheric air, or oxygen. When stored in air-tight pipes, it is just as safe as water.

It now costs from two hundred and seventy-five to three hundred dollars to burn a kiln of two hundred thousand bricks, while in the same sized kiln by my process, every brick can be burnt, and burnt hard, for one hundred and ten dollars, or fifty-five cents per thousand.

So far as I know I am the first who ever used steam in a brick kiln, to be superheated by the excess of heat in the arches, and bottom of the kiln, and to lift up this heat and distribute it in the upper parts of the kiln. My first patent for this use of steam was dated July 21, 1868. When this patent was examined by the United States Patent Office, it was found that the word steam had never been used in connection with a brick kiln in the world. This patent was taken out in 1868, in nearly every country in Europe. In the specification of the American patent, I say: "The life of my invention consists in a new method of producing, distributing, transporting, and retaining the necessary heat in all parts of the kiln, so as neither to overburn the bottom or underburn the top, but to equalize the heat of both by means of a positive, reliable, and instantaneous power, to supply any desirable degree of heat to all parts of the kiln alike. This I accomplish by the accurate and positive manner of introducing air and steam into the fire places, the former to promote perfect combustion, and the latter to become superheated, at the expense of the overheated fire places and bottom bricks, and both to carry up caloric to be distributed and utilized in raising the topmost courses to a settling heat."

Another of my patents was dated July 20, 1869, and covered some additional details, such as the building of the fire places outside of a brick kiln, and the forcing of the products of combustion into the kiln by jets of steam. Amongst the claims was one allowed in this patent for the use of steam, and is in these words: "The arrange-

ment of furnaces in a brick kiln, with jets of steam discharging into the furnaces, substantially as and for the purpose set forth." These patents were parted with soon after they were issued, but the parties holding the right so modified the disposition of the fires and introduction of the jets, that their kilns never worked satisfactorily, and the patent was generally regarded as a failure. Had the kiln been arranged as patented, with an upright draft, its success would have been perfect at the start. The control of the original patents has now reverted to me, and with a new patent, dated Nov. 23, 1875, there is secured every useful detail which experience has shown necessary to make the invention all that can be desired.

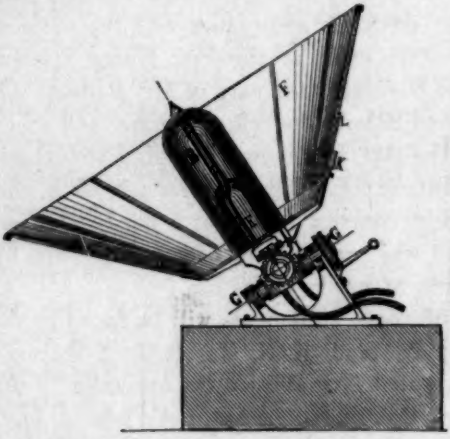
To show that these statements are supported by actual accomplishments, I will state that four kilns have been burned off this last fall, for this time with the upright draft, in accordance with the patents. These were small kilns, and were built at the Fish House Station, near Camden, by Mr. Richard D. Cox, on the yard of Mr. Reeves. All four of these kilns were burned in half the ordinary time, and every brick was perfectly hard. The last kiln is now standing for exhibition, full of bricks, just as burned off. There is not a brick in this kiln, including the top platting courses, but what is hard stretcher. It settled thirteen inches, and was burned in just forty-nine hours by a man who never burned a kiln of bricks in his life.

A further corroboration of these statements will be found in the fact that Profs. J. P. Cooke, Jr., and E. N. Horsford, of Harvard University, examined and reported favorably on the operation of the process, while the Mass. Brick Co., of Cambridge, near Boston, have put the kilns into operation with great success. When we consider that one thousand of bricks is required, to each seven or eight inhabitants of our cities per year, and that over $1.00 per thousand in price, and $1.00 per thousand in quality, is saved by the new kilns, the magnitude and the value of this improvement is made comprehensible to the minds of all.

Asphalt Pavement in England.—Much dissatisfaction has arisen from the use of this pavement in the crowded thoroughfares of London. The constant falling of horses and of men upon the smooth surface, made slippery by the thin layer of slime which the damp climate produces from street offal, has reached a point beyond the endurance of the English public. It is proposed to substitute wood pavement.

MOUCHOT'S SOLAR BOILER.*

We reproduce from our contemporary, *La Revue Industrielle*, the following illustration, and a description of an interesting apparatus constructed by M. Mouchot, Professor at the Lycée of Tours. This apparatus is, in fact, a solar boiler, and the letters upon the section refer to the following parts: A is a glass bell, B is a boiler with a double envelope, D is a steam pipe, E is a feed pipe, F is a conical silvered mirror; G G is a spindle, around which a motion is given to the machine from east to west; H is the gearing regulating the inclination of the apparatus on the spindle G G, according to the seasons; I is a safety valve; K is a pressure gauge, and L is a water gauge.



The construction of an apparatus intended to utilize the heat of the sun's rays depends on a more or less perfect knowledge of: 1. The amount of heat produced in a given time on a given surface by solar radiation. 2. The power of reflection and absorption of the different substances to be employed. According to Pouillet, if the atmosphere did not exist, there would fall per minute, on each square centimeter of the great circle forming the base of the hemisphere lighted by the sun, a quantity of heat represented by the number 1·7633, taking as a unit the amount of heat required to raise one gram of water from 0 deg. to 1 deg. In passing through the atmosphere from 21 to 28 per cent. of the heat is absorbed, even in fine weather. Forbes and Kaemtz, at the end of long investigations, arrived at the conclusion that the amount of heat which reaches the earth in this climate, is not so great as that named by Pouillet. On the other hand, the experiments of Sir John Herschel, at the Cape of Good Hope, led him to think that the solar heat, striking vertically, gave considerably less heat than was as-

* From *Engineering*, London, December 31st, 1875.

signed at Paris by Pouillet. Probably if the amount of 10 calories be taken for this climate, it will be within the mark. The investigation of Melloni demonstrated that the quantities of radiant heat transmitted by a sheet of glass, diminishes as the thickness of the glass increases. If a smoked metal plate be placed under a glass bell, the luminous rays will heat the metal, but the rays reflected from the plate will not pass through the glass; the black coating possesses to a high degree the faculty of absorbing the heat and light rays. Moreover, it resulted from the studies of MM. La Provostage and Desains, that silver is the best reflector of solar heat, and that a silvered mirror reflects about 92 per cent. of the whole. From the preceding data it appears to follow that in the construction of the solar boiler the apparatus should be placed under a glass casing, and silvered mirrors would be preferred for the concentration of the solar rays. The parabolic cylinder, and the regular truncated cone, produced by the rotation of an isosceles triangle, seem to be the best forms to adopt. These conditions have been carried out in the apparatus of M. Mouchot. It is composed of three distinct parts, the metallic mirror, the blackened boiler, the axis of which coincides with that of the mirror, and a glass envelope permitting the sun's rays to reach the boiler, but preventing their return. The ratio of the heat utilized with the surface thus isolated, increases with the extent of this surface. The mirror has the form of a truncated cone, with parallel bases, and the generating line makes an angle of 45 deg. with the axis of the cone. This is the best form that can be adopted, because the incident rays striking parallel to the axis, are reflected normally to this axis, and give a heat area of maximum intensity for a given opening of mirror. The reflectors are formed of 12 silvered sectors, carried by an iron frame, in grooves of which they slide. The diameter of opening is 112·3 in. at the top, and 39·3 in. at the bottom, giving an effective mirror area of about 45 square feet. The bottom of the mirror is formed of a cast iron disc to add weight to the apparatus. In the centre of this disc is placed the boiler, the height of which is equal to that of the mirror. It is of copper, blackened on the outside, and is formed of two concentric bell-shaped envelopes, connected at their base by a wrought iron ring. The larger envelope is 31·5 in. high, and the smaller 19·68 in.; their respective diameters are 11·02 in. and 8·66 in. The water is introduced between these two envelopes, so that it forms a cylinder 1·18 in. thick.

The amount of water does not exceed 4·4 gallons, and about one-third of the annular space is left as a steam chamber and connected with the motor by a flexible tube. At the foot of the boiler is placed the feed water tube. The glass envelope or bell is 15·75 in. in diameter, and 33·46 in. high, the thickness of the glass being ·2 in. thick. A space of nearly 2 in. is thus left between the sides of the glass and the copper envelope.

Thus arranged, the apparatus is mounted on an inclined axis, the angle of which can be made to change to correspond with the motion of the sun, and a rotating movement of 15 deg. per hour can also be given to it. To effect this double object, the apparatus is carried on trunions resting on a shaft perpendicular to their axis, and this shaft forms, from north to south with the horizon, an angle corresponding to the latitude of the place. Two movements result from this arrangement which permit the apparatus to follow the course of the sun, since by a half revolution it turns from sunrise to sunset, whilst by an annual rotation of 46 deg. at most, on the trunions, it is brought opposite the sun in all positions. This double movement is effected by means of worm gearing, the first being repeated at half hour intervals, the second every eight days.

Experiments made with this apparatus at Tours showed that in 40 minutes, 44 lbs. of water were raised from a temperature of 68 deg. to 252 deg. and thence to a pressure of 5 atmospheres. In less than 15 minutes, 33 lbs. of water of 212 deg. were raised to 307 deg. Finally, in favorable weather, 11 lbs. of water have been evaporated per hour. The steam generated was employed for driving a pump.

The inventor of this ingenious apparatus points out various uses for which it may be employed, especially in warm climates, as, for example, for the distillation of water, either on shipboard or in rainless conntries, for the manufacture of ice in connection with the Carré apparatus for the distillation of alcohol, etc., and in the manufacture of sugar.

Internal Constitution of Magnets.—In the *Comptes Rendus*, for January 3d, 1876, M. J. Jamin shows that a bundle of steel plates will always be stronger than a single bar of steel of the same dimensions, and the proportion will increase indefinitely with the number of the plates. This view justifies the use of slender laminæ in he construction of magnets.

COTTON MANUFACTURE AND THE RING FRAME.

By F. H. Silsbee.

(Continued from Vol. ci, page 101.)

Plate III, Figs. 1, 2, 3, 4, 5, 7, show some of the forms of bobbins which have been used, all except Fig. 7, having projections on the spindle which fit into the recesses shown. In Fig. 7, however, there is a spring in the bobbin which presses against the spindle, and thus holds the two together. The method, however, which is most generally used at present, is to drive them merely by the friction of the close-fitting bobbin on the spindle, notwithstanding the objection suggested by Mr. Leigh.

There has been an almost endless variety of spindles and bobbins invented, and a few of them are shown in Plates II, III, IV. The most important of all these, and those most in demand at present, are : 1st. The ordinary spindle, of which that manufactured by the Saco Water Power Company may be taken as the type, which consists of a steel rod 16½ inches long, tapering from about the middle towards each end, the largest diameter being about ⅝ inch, the smallest at the top ⅛ inch, and at the bottom ¼ inch. The wheel is placed about six inches from the bottom, and the whole weight of the spindle is about 12 ounces, although some have been made by this company as light as 7 ounces.

2d. The Sawyer Spindle, of which a drawing is shown in Plate III, Fig. 6. The bobbin is driven by friction, as in the ordinary spindle, but its distinctive feature is that the bolster *b*, is made very long, running almost half-way up inside the bobbin. This arrangement of bolster gives the requisite steadiness without necessitating such a long spindle as the common one is, and thus its weight is reduced to only about 3 or 4 ounces. The diameter of the step is also much less, being only ⅛ inch, and this fact, combined with the weight, must make the friction considerably less; but I will discuss this point at more length farther on. There is one objection made to the Sawyer and other short spindles, which seems quite reasonable; and that is, the inconvenience in banding them, in consequence of the step and bolster rails being so near together.

3d. The Rabbeth Spindle, Plate IV, which is also a very light spindle, and the bolster has a chamber which is kept filled with oil, so that the step is kept constantly lubricated, and the oiling only has to be done once in two or three weeks.

4th. The Excelsior Spindle, the peculiarity of which is, that there is a square button on the spindle, which fits a recess in the bobbin; but this necessitates the stopping of the spindle when the bobbin is removed.

5th. The Pearl, which is another of the light spindles. (Plate IV.)

All these various spindles, and a good many more which I have not mentioned, have their admirers, and it would certainly seem from a theoretical consideration merely, that a light spindle, provided it could be run as steadily, would require the least power; but, of course, the real merits of any particular spindle can be arrived at only by a practical trial.

The following is the power required to drive various kinds of frames, taken from some tests made by Mr. Webber, which were published in the report of the New England Cotton Manufacturers' Association, for 1873. The speed, in all cases, was 6000 revolutions per minute.

No. 30 Yarn.

	Ft. lbs. per Sp.
Heavy Spindle, ordinary ring-spinning, . .	7·15
Light " " " . .	6·10
Mason's Light Spindle, at Crescent Mills, . .	4·40
Rabbeth Spindle, at New Bedford, . . .	4.10
American Linen Co.'s Spindle, at Fall River, .	4·10
Garsed & Jenks' Spindle, at Philadelphia, . .	3·40

No. 40 Yarn.

Sawyer Spindle, Old Bolster, Fall River, . .	3·00
" " New " Manville, . .	2·80
Garsed & Jenks' Spindle, Manville, . . .	2·45

The matter of rings is also one which has called forth a good many inventions. Plate III, Fig. 9, shows the form of the ordinary ring excepting the projection *C*, the object of which is to clear the loose threads from the traveler; but I don't think this appendage is often used. There is also usually a shoulder just below the junction of *C* with the ring, the lower part of the ring up to this shoulder being set in the ring rail. The objection to this sort of ring driven

firmly into the rail, is, that if through any accident the hole in the rail is not exactly concentric with the spindle, it cannot be adjusted; therefore, various forms of rings have been invented to obviate this difficulty. Plate IV, Fig. 4, shows one form of adjustable ring invented by Mr. W. Jenckes, of Manchester. As will be seen from the drawing, the hole in the rail is bored larger than the ring, which is held in place by three set screws. Plate III, Fig. 8, shows another method, which consists in having a hoop of metal, with its exterior turned eccentric with its interior, fitted into the rail so that it can be turned round, and into this, the ring seating, its exterior also eccentric with its interior, is fitted. Plate IV shows various forms of ring supporters, Fig. 1, *A*, *B*, being a form invented by Mr. Shorey, which consists of a flat ring of metal, having a lip turned up as shown at *l*, and the ring being sprung under these, is held in place. Fig. 2, *C*, *D*, is a somewhat similar arrangement, invented by Mr. Sawyer, the principal difference being that the projecting lip is made all around the supporter, which is split as shown at *a*, in order that the ring may be slipped in place. Fig. 3 is another similar arrangement, patented by Mr. Draper. All these forms are specially suited for duplex race rings; that is, those having a smooth flange on the top and bottom, so that the ring can be turned over when one face becomes worn.

Let us now compare the merits of the three methods of spinning. It is generally admitted that the throstle yarn is the strongest and smoothest of the three kinds, and a good many manufactures consider that it weaves easier; but then the throstle requires more power, and can do less work in the same time. The ring yarn is stronger than the mule, and is better for the warp. The ring frame also requires a good deal less power than the throstle, although it makes a little more waste. It takes up very much less room than the mule, though it takes a little more power on the average. Several attempts have been made to spin the filling on the ring frame, and some very good cloth has been produced, but there seem at present to be several objections to its general use for filling; in the first place, the cloth woven in this way is rather harsher, owing to the necessity for putting more twist in the ring yarn; and in the second place, the shape of the bobbin is a great objection. The twist is also more even in the mule than in the ring yarn, from the fact that the yarn is stretched while being twisted, and thus any

inequalities are evened out, so that the twist does not find small places to settle in, leaving the larger parts supplied with less twist, as is apt to be the case on the ring frame. The following are the results of some tests made by Mr. Cumnock and Mr. Francis, on the strength of different yarns, and the power required to run the various kinds of spinning machines:

Throstle	Frame,	No. 32	Yarn.	Twist,	27·14.	B. Strength,	52	lbs.
Ring	"	"	"		27·20.	" "	48	"
Mule	"	"	"		27·16.	" "	41	"

POWER.

Throstle,	73	sps. per	H. P.	No. 32	Yarn.	Rev. of sp. per min.	4200
Ring,	102	"	"	"	"	"	5900
Mule,	296	"	"	"	"	"	5650

QUANTITY.

"As the twists per inch in this test were the same, or nearly so, on the three kinds named, of course the largest quantity were produced from the ring frame; then the mule; and the throstle last. The quantity, of course, would be as the speed of the spindles, everything being equal." The diagram scale on Plate IV shows the power required for different spindles, plotted from experiments made by Mr. Francis, and which are published in the report of the New England Cotton Manufacturers' Association. In this diagram, the ordinates represent foot pounds of work required, and the abscissæ the number of revolutions of the spindles per minute.

The following results of experiments made by Mr. Webber, published in one of the reports of the association above alluded to, show the advantages of various methods of banding. The tests were made:

First. On ring frames, with every spindle banded separately.

Second. With 16 spindles in a section, all on one side.

Third. With 16 spindles in a section, 8 on each side.

Fourth. With 8 spindles in a section, 4 on each side, and with the following result:

	Single Band.	16 One Side.	8 Each Side.	4 Each Side.
Rev. F. Roll,	84	84	84	84
Rev. Spindle,	5666	5666	5666	5666
H. Power, 128 Sp.,	1·667	1·707	1·485	1·364
Ft. lbs. per Sp.,	7·26	7·33	6·38	5·86
Spindles per H. P.,	77	75	86	94

These results were so striking, that after being confirmed by a second day's trial, it was decided to test the throstle frames in the other mills of Pepperell Co., which gave:

Mill No. 1, Pepperell Co., Old Lowell Throstle. Weight of Flier, 3·45 ounces.

	16 One Side.	8 Each Side.	4 Each Side.
Rev. F. Roll,	71	71	71
Rev. Spindle,	4929	4929	4929
H. Power, 128 Sp.,	2·002	1·924	1·845
Ft. lbs. per Sp.,	8·60	8·27	7·92
No. Spindles per H. P.,	64	66·2	69

Mill No. 2, Pepperell Co., Lowell Throstle, with Pearl's Improved Flier. Weighing 2·83 ounces.

	16 One Side.	8 Each Side.	4 Each Side.
Rev. F. Roll per minute,	71	71	71
Rev. Spindle,	4929	4929	4929
Horse P., 128 Spindles,	1·686	1·687	1·528
Ft. lbs. per Spindle,	7·24	6·90	6·57
Spindles per H. P.,	76	79·75	83·75

"It was not thought necessary in these mills to repeat the trials of single banding, as the previous trials on ring frames had shown an advantage in it of about two per cent. over banding 16 spindles in a section on one side, while these trials showed an average of 5 per cent. in favor of banding 8 on each side, and 4 per cent. in favor of 4 on each side.

"The cause of this saving of power seems to be this: That the drums or cylinders are kept exactly in the centre of the frame, by this mode of banding, without any unequal pressure on either side, such as would be inevitably caused by a tight band, if put on in the usual manner; and it may be worth while to follow the experiment still farther, testing 4 spindles in a section, 2 on each side, and even down to 2 spindles banded directly across the frame, with one turn round the cylinder in the centre."

It may not be out of place here, before taking up the subject of twist, and one or two other calculations in regard to the ring frame, to say a word or two on the manner in which yarn is numbered.

The number given to cotton yarn, is in all cases the number of hanks which it takes of that yarn to weigh one pound. Thus, when No. 27 yarn is spoken of, it means that 27 hanks weigh one pound.

Now, a hank is 840 yards or 2520 feet; therefore, it takes 12·86 miles of No. 27 yarn to weigh one pound.

The numbers of the yarn used for ordinary cloth may vary from 20 to 100, although coarser numbers are used for making cotton duck, and finer numbers are employed for laces and muslins, very seldom exceeding No. 300; it is stated, however, that Messrs. Houldsworth, of Manchester, England, exhibited, in 1851, some lace made of No. 600, or so fine that it would take 286·66 miles to weigh one pound, and it also stated that the same firm exhibited some No. 2150, which would require 1026·13 miles to weigh one pound.

There is another point which it will be well to take up before considering the subject of twist, and that is, what relation exists between the speed of the traveler and of the spindle, a relationship which, at first sight, it does not seem very easy to determine. It is evident that if the traveler did not move, the yarn would be wrapped round the bobbin once for every revolution of the spindle, or else the yarn would break, and that if the traveler had the same speed as the bobbin, no yarn would be wound on; but now the traveler does move, and yet the yarn is wound on; therefore, evidently, the traveler must have a different speed from the bobbin; but, now what, exactly, is that difference? I hope the following explanation will make it clear. Consider, in the first place, that the yarn is stretched from the rolls, through the traveler, to the bobbin, and that the bobbin is then made to rotate rapidly, no more yarn being delivered. Evidently, if the yarn is strong enough, the traveler will have to make just as many revolutions as the bobbin, but the traveler has a tendency all the time to hold back, caused by its friction against the ring, and would therefore stop if it were not pulled along by the yarn. Now, suppose the circumference of the bobbin to be three inches, and let the front roll instantly deliver one inch of yarn; evidently the pull on the traveler will cease; therefore, the traveler will stop till the yarn begins to pull again, which will be when the 1 inch has been wound on. But since the circumference of the bobbin is three inches, the spindle must evidently make one-third of a revolution before the one inch is wound on. Therefore, the bobbin will have made one-third of a revolution more than the traveler. Hence, when the yarn has been wound about the bobbin once, the bobbin will have made just one more revolution than the traveler. Of course, in practice, the yarn is being constantly delivered, and the traveler never really stops, but the

tendency to do so, and the consequent diminution of speed of the traveler is the same; and we come to the following conclusion: That the difference between the number of revolutions made by the bobbin, and that made by the traveler, is equal to the number of times the yarn has been wound round the bobbin during the same interval of time.

Before giving the ordinary rules for calculating the twist, it is necessary to point out that there is a difference between the number of twists in the yarn as it lies on the bobbin, and the number of twists after the yarn is wound off in the usual manner; the former may be called the real twist, and the latter the apparent twist. This difference can perhaps be best explained by an example. If you take a piece of tape, and wind it spirally round a pencil, you do not appear to have twisted it all; but now pull the tape off the end of the pencil, holding one end of the tape firmly on the pencil, and you will see that the tape is twisted, and this shows the real twist which was in the tape while on the pencil, only it was not apparent. The apparent twist will be the twist left if you unwind the tape from the pencil, instead of pulling it off. In this case, the apparent twist will be nothing, because you untwist in removing the yarn, as much as you twisted in winding it on. Now, take a case a little more like what occurs in practice, and instead of winding up the tape for every revolution of the pencil, let it only wind up the tape once for every twenty revolutions of the pencil, and suppose you wind the tape four times around it, evidently the real twist will be 80, while the apparent twist is only 76. Now, this apparent twist is what is actually used in yarn made on ring frames, except where it is used for filling. Of course, if the one twist was always taken out of the same length of yarn, the twist per inch remaining would be the same for all parts of the bobbin; but such is not the case; for, as the bobbin increases in size, its circumference increases, and as there is one twist taken out for each wrap of the yarn around the bobbin, and this one twist has to be divided by the number of inches over which it extends, the number of twists per inch taken out must be less when the bobbin is full. I will give an example farther on to show how much error this causes.

I will now take an example to show the method of calculating the twist (real) put in the yarn when the speed of the cylinder and spindles, and the number of teeth on the wheels (if driven by gears),

or the diameters of the wheels (if driven by belts), which convey the power to the point roll are given. The example is taken from a ring frame made by the Saco Water Power Company, in the Naumkeag Mills, at Salem, the following data being given :

Speed of Cylinder, ...	870 revs. per min.	$= a.$
Diam. of Pulley on Cylinder, . .	4·75″	$= b.$
" " Twist Pulley, . . .	10·50″	$= c.$
Teeth in Twist Gear, ...	24	$= l.$
" " Gear on Front Roll, . .	132	$= f.$
Circumference of " . .	3·1416	$= k.$
Speed of Spindles, ...	6090	$= n.$

Then speed of twist gear = speed of twist pulley $= \frac{a \times b}{c} =$ $\frac{870 \times 4{\cdot}75}{10{\cdot}5} = 393{\cdot}57 = d.$ Speed of front roll $= \frac{d \times l}{f} =$ $\frac{393{\cdot}57 \times 24}{132} = 71{\cdot}55$ revolutions per minute.

$\therefore$ Number of inches of yarn passed through the front rolls, per minute $= 71{\cdot}55 \times k = 224{\cdot}667$. $\therefore$ The number of twists put in one inch of yarn $= \frac{n = 6090}{224{\cdot}667} = 27{\cdot}10$, which gives the real twist per inch. To calculate the mean apparent twist, we must divide the number of inches delivered by the front roll, by the mean speed of the traveler, which we will consider to be the speed when the bobbin is half full. Now, when the bobbin is half full, its circumference is usually about 3·1416. $\therefore$ According to what has already been said, the speed of the traveler $= 6090 - \frac{224{\cdot}667}{3{\cdot}1426} = 6018{\cdot}49$. $\therefore$ The mean apparent twist $= \frac{6018{\cdot}49}{224{\cdot}667} = 26{\cdot}78$. Calling the mean speed of the traveler n', we have for the general formula for finding the twist,

$\frac{n \times c \times f}{a \times b \times l \times k} =$ the real twist per inch.

$\frac{n' \times c \times f}{a \times b \times l \times k} =$ the mean apparent twist per inch.

Now let us see how much inequality there is in the apparent twist, arising from the varying size of the bobbin ; and for this purpose we will calculate the twist at three points, *i. e.*, when the bobbin is empty, when it is half full, and when it is full, and we will take the

same yarn that we used before, for which the real twist is 27·106, the following data being given :

Circumference of empty bobbin = 1·57 inches.
" " half full " = 3·1416 "
" " full " = 4·712 "

Then in the 1st case, the twist taken out per inch $= \frac{1}{1{\cdot}57} = {\cdot}6369$.

In the 2d case, $\frac{1}{3{\cdot}1416} = {\cdot}3185$. In the 3d case, $\frac{1}{4{\cdot}712} = {\cdot}2123$.

∴ We have for the apparent twist per inch :

In the { 1st case, 26·469.
2d case, 26·787.
3d case, 26·8937.

This calculation shows that there is a little difference in the twist at different points in the yarn, but this is so slight that it may be neglected in practice ; and, indeed, some manufacturers take the amount of real twist for the apparent twist.

There might at first thought seem to be an unevenness of twist arising from the constantly varying distance of the ring rail from the front rolls. But I think it can be proved that this makes no error. Let the distance from the front roll to the traveler, when the ring rail is in its lowest position, be greater than the distance to the traveler, when the rail is in its highest position, by a quantity c, and let $S =$ the circumference of the bobbin, and $d =$ the amount of yarn passed through the front rolls per minute. Then, when the ring rail is in its highest position, the time taken to wrap the yarn once round the bobbin $= \frac{S}{d}$, and in the time $\frac{S}{d}$, the spindle will make $\frac{S}{d} \times n$ revolutions. So that the real twist per inch $= \frac{\frac{S}{d}}{Sn} = \frac{d}{n}$.

When the ring rail is in its lowest position, the amount of yarn required to reach the bobbin and wrap once around it, will be greater by c than the length required before. ∴ The time required to wrap the yarn once round $= \frac{S+c}{d}$ and in that time the spindle will make $\frac{(S+c)n}{d}$ revolutions. So the number of twists per inch =

$\frac{S+c}{\frac{(S+c)n}{d}} = \frac{d}{n}$. ∴ The amount of twist which will be put in one inch is the same in both cases, and is, therefore, independent of the position of the ring rail. If the real twist does not vary, the apparent cannot.

The amount of twist put into the yarn varies with the number, the customary rule being: No. of twist per inch $= c\sqrt{\text{No. of the yarn}}$, the value of c being taken by some as 5, by others, 4·5. Examples: Required the number of twists for No. 9 yarn. Answer, $5\sqrt{9} = 15$.

The number of twists for No. 25 yarn $= 5\sqrt{25} = 25$.

The number of twists for No. 100 yarn $= 5\sqrt{100} = 50$.

Thus it will be seen, that the number of twists may be greater, as well as less than the number of the yarn.

To calculate the actual draught on a ring frame with the following data given:

Back roll gear, ...	84 teeth.
Stud gear, ...	84 "
Front roll gear, ...	30 "
Diameter of back roll, ...	$\frac{7}{8}$ inch.
" " front "	1 inches.
Pinion gear, ...	37 teeth.

The draught $= \frac{84 \times 84 \times 8}{30 \times 7 \times 37} = 7{\cdot}26$.

The draught is changed by changing the pinion gear, which together with the stud gear is placed on a movable stud for that purpose. Required the number of teeth x on the pinion gear, for a given draught D, the data being the same as before:

$$x = \frac{84 \times 84 \times 8}{30 \times 7 \times D} = \frac{268{\cdot}88}{D}.$$

The amount of draught depends on the relative speed of the front and back rolls, and the twist on the actual speed of the front roll with regard to speed of spindles. The spindles are run at the same speed, whatever the number of the yarn. Almost all the yarn finer than No. 60, is spun on the mule, and most spinners think it is impossible to spin any finer yarn on the ring frame, but a gentleman who has had great experience in spinning fine yarns, told me that this was a mistaken idea, and that by using long stapled cotton, he had spun No. 80 on the ring frame, and intended to spin No. 100.

The following calculation shows the speed of the traveler through space when under the following conditions:

The number of revolutions of the spindle = 6000 per minute.

The average circumference of bobbin = 3 inches.

The amount of yarn delivered by front roll = 224·667.

The radius of the path moved through by the centre of the traveler = $\frac{1}{8}$ inch.

Then the number of revolutions the traveler will make per minute

$$= 6000 - \frac{224 \cdot 667}{3 \cdot 1416} = 5925 \cdot 12.$$

And the space passed through in one revolution = $2\pi \times \frac{1}{8} = 5 \cdot 4978''$, and for 5925·12 revolutions = 32570·384 inches per minute = 1954222·8 inches = 30·84 miles per hour.

We will now examine the difference between the power required to drive the Saco spindle and the Sawyer spindle, and endeavor to see what proportion of this saving of power is due to the difference in weight.

First, to determine the friction of the Sawyer spindle, with the following data given:

Weight of Sawyer spindle, with empty bobbin = 3·5 ounces.

Number of revolutions per minute = 5000.

Diameter of step = 1-16 inch. ∴ Radius of step = 1-32 inch.

Conical pivot, the sides making an angle of 90° with each other.

Coefficient of friction = f = ·07.

We have the following formula for the friction of conical pivots:

$$\text{Total work of friction} = \frac{\pi n r f W}{15 \sin a}.$$

Where $\pi = 3 \cdot 1416$.

n = number of revolutions per minute.

r = radius of the pivot in feet.

f = the coefficient of friction.

W = the weight in pounds.

$a = \frac{1}{2}$ the angle between the sides.

Substituting in this formula the values given above, we have the

$$\text{friction} = \frac{3 \cdot 1416 \times 5000 \times \cdot 07 \times 3 \cdot 5}{15 \times \cdot 70711 \times 32 \times 12 \times 16} = \cdot 059 \text{ ft. lbs. per second.}$$

Now, we have for the whole power required to drive the frame at 5000 revolutions per minute on No. 30 yarn = 3·25 ft. lbs.; therefore, the percentage of that power required to overcome the friction

arising from the weight and diameter of the step alone = ·0182 per cent. Applying the same formula to the McMullen (Saco) spindle, where the following data are given :

Weight of spindle with empty bobbin, 11 ounces.

Number of revolutions per minute, 5000.

Diameter of step, $\frac{1}{4}$ inch.

Angle of pivot = 90°. ∴ $a = 45°$.

Coefficient of friction = ·07.

We have for the total work of friction = $T' = \frac{3{\cdot}1416 \times 5000}{15 \times {\cdot}70711} \times \frac{1}{8 \times 12} \times {\cdot}07 \times \frac{11}{16} = {\cdot}74$ ft. lbs. per second. Now, the power required to drive this frame on No. 30 yarn, at 5000 revolutions per minute = 5·1 ft. lbs. per spindle. ∴ The percentage of power wasted in overcoming friction due to the weight of the spindle and empty bobbin, and diameter of step = ·0145 per cent.

The difference of power required to drive the two different frames = 5·1 — 3·25 = 1·85 ft. lbs., while the difference in the amount of work lost by friction = ·74 — ·059 = ·681 ft. lbs. ; therefore, the percentage of the saving due to the difference in friction = 36 per cent. The same calculation would apply almost equally well to the Rabbeth spindle, which is of about the same weight. This calculation seems to show that only a comparatively small proportion of the saving of power, found in using these light spindles, is due to their less weight. The rest of the saving is due probably to the smaller diameter of the bolster bearing, and to the fact that, since less power is required, the band does not have to be drawn so tight, and, therefore, there is very much less friction at the bolster.

The tightness of the bands is always a matter which makes a great difference in the power required to drive any frame, and, as the bands have to be adjusted by guess, it is probable that in most cases they are made considerably tighter than is necessary, from the desire to be sure and have them tight enough, and it is a well-known fact, that if, after a test has been made, the bands are cut, and the frame rebanded, the power required will be very different from what it was before.*

* The bands, as originally placed, require much extra power from unnecessary tension ; but after running some time, they stretch to the least point of tightness demanded, and then run with a minimum expenditure of power, before the spindles fail to have requisite speed.

I have endeavored in this paper to point out some of the advantages and defects in the ring frame, and some of the various spindles employed.

There seems to be now no doubt but that the ring frame is, in many respects, a great improvement over the machines formerly used for spinning, especially for spinning the warp; but still there is room for improvement in this machine, as well as in all the others employed in the cotton manufacture, and a vast amount of attention has been paid to the subject, especially to the reduction of the power required to drive spindles. It may at first seem that the saving of one or two foot pounds per spindle is a very slight matter, but it must be remembered that each frame has from 180 to 190, spindles, and when we take into account the number of spindles every mill has, this little saving amounts to quite an important item.

Immense as has been the improvement both in the machinery and reduction of cost of manufacture in this country since the first factory was built at Beverly, it does not seem improbable that there may be still further improvements in the future, as important, though perhaps not so marked as those which have already been made; and we may justly congratulate ourselves that Americans have helped not a little in the rapid growth of this industry by their improved steam engines and water wheels, and their methods of belting and shafting, which have had a great influence on the increase of the cotton manufacture.

THE UNDERGROUND TELEGRAPHS OF LONDON.*

On the 8th inst., at the meeting of the Society of Telegraphic Engineers, held at the Institution of Civil Engineers, Great George Street, Westminster, the president, Mr. Latimer Clark, in the chair, an interesting paper on "Underground Telegraphs; the London Street Work," by Charles Fleetwood, of the Postal Telegraph Department, was read.

The author stated that from the original five wires used by Cooke & Wheatstone, in July, 1837, between Euston and Camden, to test the success of the original five-needle telegraph, the system has gone on increasing latterly with rapid strides, culminating at the present time with 750 different wires entering the central station, and a total

* From the *Builder*, London, December 18th, 1875.

mileage of 3500 miles of gutta-percha covered wire. On the successful issue of the Cooke & Wheatstone telegraph, it was started commercially; and a line of five wires was placed underground in lead pipes between Paddington and Drayton. This line became defective, and in 1841 was replaced by posts and overhead wires. The existing lines erected by Mr. Cooke, from this period, were, in 1846, on the incorporation of the Electric Telegraph Company, led by wires in iron pipes to the first office in London, 345 Strand. In the following year, the system was extended under the streets to their new Central Station, at Founder's-court, Lothbury, which office was opened January 1st, 1848, when the total system of the company at that time reached 1500 miles of telegraph wire erected and in progress, a mileage less than one-half the present system under the streets of London alone. The wires were formed into cables, and drawn through iron pipes; the wires were of No. 4 gauge. These cables were connected to what were termed testing posts, standing up like a street post. The wires were connected in these boxes by a mechanical joint, which it was easy to open and disconnect for testing.

At the present time, the street work of London consists of about 3500 miles of No. 7 gauge gutta-percha covered wire, wrapped with tape, and tarred, drawn into cast iron pipes of 3 inches, and in some cases 4 inches diameter. This system connects the central office at St. Martin's-le-Grand with the several provincial railways, and the main road lines of telegraphs; it also serves a large number of the metropolitan telegraph offices. After describing the main routes of the pipes through the various districts of London, for a length of 110 miles, the author went on to state, that at the New General Post-office, the whole of the 740 wires are carried up the interior of the building, and terminate on a test box, where each wire is numbered. Provision has been made on this box for 500 wires from the west, and a corresponding number from the east, a total of 1000 in all. A 4-inch pipe will hold 120 wires of No. 7 gauge prepared, and a 3-inch pipe 72 wires; but it is not well, unless compelled by circumstances, to draw in those numbers. The pipes are 9 feet long, and previously to being laid, are well cleaned inside by having a heavy chain or mandril drawn to and fro to rub off any superfluous substance left in casting. The socket joints are packed with tarred yarn, and lead run in, as in the case of gas or water pipe joints.

In marking out the route, the footpath is generally chosen, and the pipes are laid under the pavement, it being more accessible, especially since the asphalt has been introduced. Flush-boxes 2 feet 6 inches long, 11 inches wide, and 1 foot deep, are fixed, in some cases 50 yards apart, and in others 100 yards, according to the number of wires required, and the nature of the streets. A No. 8 galvanized iron wire is threaded through the pipes from box to box, as the pipes are laid, by which the cables are hauled through. All the cables are sent out from the Postal Stores in lengths of 400 yards. On arrival at the place where they are to be used, the cable is coiled in a loop, a short distance from the centre flush-box of the 400 yards length. The ends of the wire are trimmed for about 6 inches. The cable is then divided into two, and each portion being twisted, is then passed through the loop in the iron leading-in wire in contrary directions, beaten back, and secured. A piece of canvas is then wrapped round and fastened with string. An iron frame with wooden rollers is then fixed in the flush-box. The cable is made to pass over one roller and under the other, and the latter is so arranged that the cable enters the pipe with a clear lead, and without being chafed against its edges. All being now ready for the drawing in, two men stand within the coil cutting the ties, and delivering the cable to a third man over the flush-box, whose duty it is to see that the cable enters the pipe evenly, the foreman standing near, so as to watch the cable entering the pipe, and to signal to the men at the next box when to commence or cease pulling. When the first 50 yards of cable have entered the pipe, which is known by the end appearing at the next box, a piece of tape is tied round the cable; and when this has passed through the pipe, a second piece, and so on, till the 200 yards have been drawn through. As the cable comes out of the pipe, it is coiled on the opposite end to that from which it has been drawn; the cable is then turned over by being re-coiled on to the contrary end of the box ready again to enter the pipe. This operation is repeated till the whole 200 yards have been laid. A corresponding operation has to be performed with the remaining 200 yards of the cable, but, of course, in the opposite direction. As soon as a few sections of the cable have been laid, the jointers follow, starting from the Central Station, St. Martin's-le-Grand, and jointing the wires in the vaults under the pavement at the corner of Bath Street, Newgate Street, to the house wires leading from the

test-box in the instrument-room, and which pass through a rack numbered to correspond with the terminals on the test-box. Having completed the joints at that spot, one man proceeds to the next joint-box, 400 yards distant, and the other to the test-box, where he commences numbering the wires by putting the current on the lowest number through a galvanometer, and when found by the man in the flush-box, three signals are passed twice each way. The wire is then fitted with a small piece of composite tube, on which a number has been stamped corresponding with the test-box number. Every wire is numbered in this way at the 400 yards boxes, so that at every joint box the number of any wire is at once known. The men engaged in this work in London have had great experience, and although the whole of their joints will not, perhaps, to use their own phrase, "stand the shadow test" (Thomson's Reflecting Galvanometer), they are generally good. The greatest enemy they have to contend with is dirt, and although full instructions are issued, and every care taken, it is difficult to carry them out thoroughly in the streets of London. There have been several methods proposed for improving the joints in the streets, but as yet they have met little favor from those engaged in the work. It has been the custom to make a twist-joint, and now it has been suggested to insert the ends after being cleaned, into a piece of slit copper tube, tinned on the inside, of about $\frac{3}{4}$ inch in length, after which it is soldered. This makes a good joint, and it is believed will prove beneficial, as it does away with the sharp points that must be left when a twist is made. A plan for insulating joints is on trial at several places. The two wires are passed through the wooden bottom of a short tin tube, the twist made and soldered, and then the wires pulled back into the tube, and the latter filled with melted paraffine wax. Such a system of mechanical jointing of course could not be used where it would be necessary to draw the joints through a pipe.

On the subject of maintenance, the author stated that within the past five years nearly the whole of the underground system in London has been re-laid, the number of wires having been found insufficient to meet the increased metropolitan traffic, as well as the additional wires rendered necessary on the railways and road lines for the rapidly developing provincial business. This work has been effected with comparatively little or no interruption of the working circuits, and by far less than is experienced from renewals on railways or road lines.

The underground wires are tested periodically from the Central Station by means of a Wheatstone bridge and Thomson's galvanometer. To prevent stopping the circuit, two spare wires (where available) are used between St. Martin's and the point to which the tests are to be taken: one joined to an instrument for a speaking circuit, and the second as a substitute for the working wire during the time it is being tested. . . . During the latter portion of the time that the old building in Telegraph Street was in use, it frequently happened that a wire was worked out of a mass where there was nothing to identify it by. In that case, rather than prick the wires, a wire-finder, such as mentioned by Mr. Culley, in his Handbook of Practical Telegraphy, was used, but it was found to be a difficult task, owing to the currents in the working wires affecting the needle. Eventually it struck the author, that if he used a quantity current, and the horizontal galvanometer, generally used for the Wheatstone Bridge, he should succeed. It proved to be correct; the quantity current only moving the needle. This plan has since been used in the street, and answers admirably. In conclusion, the author expressed a hope that he might see the underground system extended far beyond the outskirts of London, believing that if the same care and attention were given to it as is given to submarine cables, it would prove to be a great success.

RAINFALL ON THE BASIN OF THE SCHUYLKILL RIVER.

By Henry P. M. Birkinbine, C. E.

The following abstract from notes made during the years 1867 to 1870, when the writer was Chief Engineer of the Water Department of the city of Philadelphia, is presented with some hesitancy, because of its incompleteness as a full consideration of the subject. At the time of change in the office of Engineer, an extensive set of observations was in progress, or on the point of institution, which, after completion, would have permitted a thorough exhibition of the physical character of the district from which the water of Philadelphia is derived; as it is, however, the subjoined notes may possess some value for the purposes of estimate.

The Schuylkill River has its rise in the Blue Mountains, and flows about southeast, draining a diversified country, about one-half of which is mountainous or hilly, and all of it undulating.

Drainage Area.—The water shed above Fairmount dam includes an area of one thousand, nine hundred and forty two (1942) square miles and occupies parts of eight (8) counties, as follows:

Philadelphia	County,	22 sq. miles.
Montgomery	"	396 "
Bucks	"	82 "
Chester	"	161 "
Berks,	"	841 "
Lehigh,	"	73 "
Lebanon,	"	43 "
Schuylkill,	"	324 "
Total,		1942 "

Average and available rainfall.—The average annual rainfall upon this area is forty-five (45) inches; of this amount about 40 per cent. (eighteen inches) reaches the Fairmount dam, the remainder being lost by evaporation and absorption. The average rainfall was determined by a careful tabulation of monthly reports of observations made at various points in the Schuylkill valley; these reports extended in two instances, viz: Philadelphia and Lebanon, over a period of forty years. The following data formed the basis upon which the estimate of 18 inches available precipitation was made.

Boston.—The average rainfall collected from the area drained from Lake Cochituate, from which Boston is supplied, is forty-six (46) per cent. of the precipitation, vide: "History of the introduction of pure water into the city of Boston." Boston, 1868, table No. 2, page 275.

Brooklyn.—The ponds from which Brooklyn is supplied collect fifty (50) per cent. of the total rainfall upon their drainage areas, vide: "Brooklyn water works and sewers." New York, 1867, page 65.

Mississippi River.—In the "Report upon the physics and hydraulics of the Mississippi River," by Humphreys and Abbot, Philadelphia, 1861, page 136. The available percentage of the rainfall upon the drainage area is given as follows:

Small tributaries,	90 per cent.
Ohio River,	24 "
Upper Mississippi River,	24 "
Missouri River,	15 "
Entire Mississippi River, exclusive of Red River,	25 "

Croton River.—The minimum flow of the Croton River, by measurement, is 0·3 cubic ft. per second, for every one thousand (1000) acres; or one hundred and twenty-four thousand, four hundred and sixteen (124,416) gallons per day per square mile, vide: "Brooklyn water works and sewers." New York, 1867, pages 63 and 64.

Evaporation.—During the summer months the evaporation averages 0·115 inches per day from the surface of the water, vide: "Twentieth annual report of the Croton Aqueduct Department." New York, 1868, Doc. 2, page 10.

Daily flow of Schuylkill.—The average annual rainfall may therefore be assumed at forty-five (45) inches, of which eighteen inches is discharged into the Fairmount Pool; this will give a daily flow of one billion, six hundred and sixty-four million, three hundred and sixty-nine thousand and four hundred and thirteen (1,664,369,413) gallons.

Freshets.—In times of freshets, a very large amount of water wastes over the dam; this will probably reach an average throughout the year of one billion (1,000,000,000) gallons per day.

Ordinary flow of Schuylkill.—The daily average flow of the stream at its ordinary stages is therefore about six hundred and fifty million (650,000,000) gallons, which would give a head of five and one-half (5½) inches above the comb of Fairmount Dam.

20-*inch Freshet.*—A freshet of twenty (20) inches on the dam will waste over four billion (4,000,000,000) gallons per day.

25-*inch Freshet.*—The head of water on the dam May 3d, 1869, was twenty-five (25) inches; this is equivalent to a daily flow of six billion, six hundred million, six hundred thousand (6,600,600,000) gallons. And on September 27th, 1869, there was *a head of thirty-six* (36) inches on the dam, which is equivalent to a daily flow of thirteen billion, six hundred million (13,600,000,000) gallons.

Formula.—These calculations are based upon the formula $Q = 3{\cdot}01208lh^{1{\cdot}55}$, when Q = cubic feet per second. This formula is given by Jas. B. Francis, C.E., and is the result of experiments made at Lawrence, Mass., on a dam having an overfall nine hundred (900) feet long, erected across the Merrimac River by the Essex Water Company, vide: "Lowell Hydraulic Experiments." Boston, 1865, and New York, 1868, page 136.

Effects of Forests.—The annual amount of water flowing in a river is about the same for each year, but by cutting off the forests and

cultivating the land, storm water flows off more rapidly and the amount of spring water is lessened, thereby augmenting the maximum and decreasing the minimum discharge of the stream, and causing the maximum and minimum flow to be more frequent and farther removed from the mean, vide: "Man and Nature," by Geo. P. Marsh, New York, 1864.

Noticed on the Schuylkill.—The effects of forests upon springs and streams of water has been frequently observed in the cutting off and the growth of chestnut trees, on the Schuylkill drainage.

Minimum flow.—The minimum flow of the Schuylkill is frequently less than two hundred million (200,000,000) gallons per day; as shown by the amount of water which is available for pumping in dry seasons.

Calculation of flow.—Taking as a basis of calculation the minimum flow of the Croton River, 0·3 cubic feet per one thousand (1000) acres; would give a discharge from the Schuylkill drainage of two hundred and forty-one million, six hundred and fifteen thousand, eight hundred and seventy-two (241, 615,872) gallons per day; from this must be deducted the evaporation in the summer months, viz: 0·115 inches. Assuming the superficial area of the river, dams, pools, etc., to be twenty (20) square miles; this amount will be thirty-nine million, nine hundred and seventy-one thousand, three hundred and thirty-nine (39,971,339) gallons—giving as the minimum flow two hundred and one million, six hundred and forty-four thousand, five hundred and thirty-four (201,644,534) gallons per day.

Store reservoirs.—During seasons of drought it was found not possible to maintain navigation by the natural flow of the river; it therefore became necessary to construct impounding reservoirs near the head waters.

Tumbling Run No. 1.—The first of these was completed upon Tumbling Run in 1834, vide: "Annual Report of the Schuylkill Navigation Company for 1834," page 6.

Tumbling Run No. 2.—A second was completed in 1837 upon the same stream, and both raised in 1840, to increase their capacity, vide: "Annual Report of the Schuylkill Navigation Company for 1840, page 9."

Silver Creek.—A third was constructed about 1854 upon Silver Creek.

Sizes and capacities.—The sizes and capacities of these reservoirs are as follows:

	Depth of water in ft. and in.	Area of water in Acres.	Contents in gallons.
Tumbling Run No 1, . . .	53′ 8″	25·57	191,598,900
" " " 2, . . .	57′	31·45	298,924,590
Silver Creek Reservoir, . . .	37′	42·	320,853,750
Total Capacity,			811,377,240

Navigation interrupted.—When any one of these reservoirs was out of order, navigation of the river has been interrupted.

Reservoirs insufficient.—The total capacity of these reservoirs, eight hundred and eleven million, three hundred and seventy-seven thousand, two hundred and forty (811,377,240) gallons, is not sufficient to keep up the mean flow of the river at Fairmount for two (2) days.

Table of Rainfall.

TIME.	Philadelphia. Penna. Hospital, 40 years' observation.			Lebanon. Union Canal Office, 40 years' observation.			Norristown. Average for 9 years.	Philadelphia. Average for 18 years; John Kilpatrick.
	Monthly Average.	Monthly Maximum.	Monthly Minimum.	Monthly Average.	Monthly Maximum.	Monthly Minimum.		
December	3·948	7·878	1·044	3·31	6·68	0·86	3·97	3·798
January	3·502	7·837	0·730	3·11	5·61	1·09	3·82	3·179
February	3·022	6·615	0·551	2·54	5·05	0·56	3·17	3·306
March	3·47	6·985	1·087	3·07	6·65	0·59	2·6	3·536
April	3·638	7·750	0·585	3·29	5·67	0·57	5·10	4·354
May	4·025	8·685	1·07	4·56	10·65	1·17	4·50	4·973
June	4·287	11·025	1·100	4·38	10·05	0·49	4·41	4·688
July	3·864	11·805	0·985	4·00	11·43	0·39	3·67	3·534
August	4·399	15·816	0·62	3·37	12·91	0·80	4·22	4·411
September	3·774	9·519	0·249	3·5	10·20	0·71	4·34	4·529
October	3·287	10·05	0·66	3·33	7·39	1·14	2·96	2·951
November	3·493	7·970	1.450	3·25	6·65	0·70	3·71	3·613
Winter	10·472	16·677	5·434	8·94	15·31	5·06	10·96	10·279
Spring	11·133	17·650	6·594	10·96	16·71	5·82	12·21	12·989
Summer	12·5	29·228	6·256	11·79	22·05	5·86	12·30	12·416
Autumn	10·554	17·765	5·245	10·11	15·81	5·99	11·01	11·092
Year	45·884			42·126			46·48	46·948
Monthly Average	3·824			3·494			3·873	3·912

River below Reading.—The river below Reading is broader, the fall of the water is less rapid, the dams cover a larger surface, and

the evaporation is greater. The amount of water necessary to keep up the navigation upon this part of the stream will therefore be much in excess of the quantity required for the same purpose above Reading.

Average Summer rainfall.

Philadelphia for	40	years,	12·5 inches.
"	18	"	12·416 "
Lebanon*	40	"	11·79 "
Norristown,	9	"	12·30 "
Average on Schuylkill drainage,			12·251 "

Observations of declivity of the river.—Efforts have been made to determine the fall or declivity of the river, produced by the flow of a given amount of water. A number of simultaneous observations were made at five points, viz: Fairmount dam, under Columbia Bridge, under City Bridge at Falls, at Pencoyd Iron Works, and at Manayunk Locks.

Constant variations of declivity.—These observations demonstrate a constant variation, caused by starting and stopping the wheels at Fairmount Water Works, or at various factories, the lockage of boats, the direction and intensity of the wind, etc.

Calculation impossible.—The declivity cannot be determined by calculation, as there are no formulæ which meet the conditions of the river varying so much in width, with so many bends, and with a bed obstructed by rocks, shoals, coffer dams, bridge piers, etc.

Measurements made August 31, 1870.—The nearest approach to determining the correct declivity was made August 31st, 1870, when the estimated daily flow was five hundred and eighty-five million (585,000,000) gallons; the surface of the water under Columbia Bridge was two and three-fourths ($2\frac{3}{4}$) inches. The surface of the water under the City Bridge at Falls, three and a half ($3\frac{1}{2}$) inches. The surface of the water opposite Pencoyd Iron Works, five (5) inches and the surface of the water at Manayunk, six (6) inches. These heights are above the level of the water on Fairmount dam, and represent the approximate declivity of the river at its ordinary stage.

Practically no declivity during minimum flow.—The quantity of water flowing in the stream materially influences the fall. When the mills and navigation are stopped, and the flow of the water is reduced

* Lebanon is situated on the water shed dividing the drainage of the Schuylkill and Susquehanna, 86 miles from Philadelphia and 456 feet above tide.

to that which leaks through the locks, dams and wickets, there is practically no declivity in the stream.

Declivity during freshet, Oct. 4th, 1869.—The greatest recorded freshet in the Schuylkill occurred October 4th, 1869, when there was 11·46 feet of water on the Fairmount dam. The declivity of the surface of the water was over twenty (20) feet in six and two-thirds ($6\frac{2}{3}$) miles. The fall was not uniform, but consisted of a series of inclines and varied from less than a half ($\frac{1}{2}$) foot to nearly (10) feet per mile, vide: "Second Annual Report of the Commissioners of Fairmount Park," Philadelphia, 1870, pp. 39 and 40.

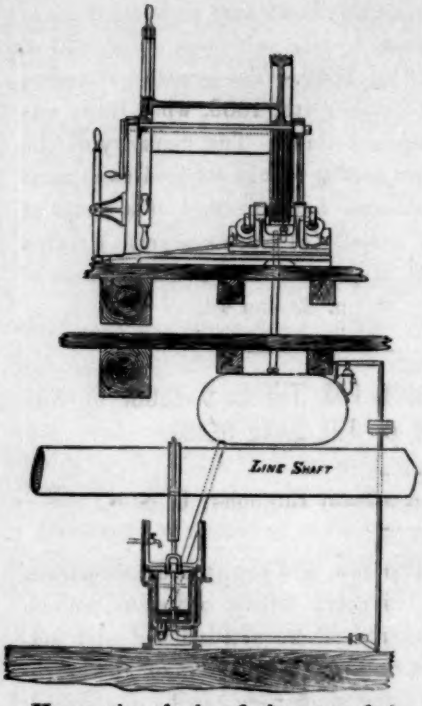
PNEUMATIC STEERING GEAR, DESIGNED FOR THE U. S. SLOOP OF WAR MOHICAN AND OTHERS OF THE SAME CLASS.

By G. W. Baird, Passed Assistant Engineer, U. S. N.

These new ships of war are unarmored, and are to compose part of our fast-cruising ships. They are to carry heavy ordnance, and to be full steam powered, and will, therefore, be well ladened with machinery, coal, ammunition, etc., leaving scanty quarters for the berthing of the crew. If, then, labor-saving machinery can be introduced, part of the crew may be dispensed with, leaving quite comfortable quarters for those employed. The Navy Department has recognized this condition of affairs, and is now introducing labor-saving machinery with this view.

But in these unarmored ships of war, steam steering gears cannot be used, as they are exposed to the shots of the enemy. Several power gears have been proposed, prominent among which are the hydraulic gears and screw gears, but have been rejected on account of their rigidity. When the rudder receives a blow from a surging wave, it must yield a little, or it will soon break, and for this purpose positive cushioning must be provided. To meet the requirements of this special case, a pneumatic arrangement has been designed in the Bureau of Steam Engineering, which has received general approbation.

It must here be mentioned that the ships of our navy, when proceeding under sail, uncouple the line shaft from the main engine, and permit the screw to revolve freely by the pressure of the water upon the blades, and with it, of course, that section of the line shaft aft of the coupling revolves.



Upon this line shaft is keyed an eccentric which works an air pump, and the air, forced by the pump is stored up in a reservoir to 55 pounds pressure above the atmosphere. Upon the *receiving* pipe of the air pump is a cock, which is opened or closed by the intervention of levers, a rod and a small piston within a cylinder on the reservoir, which is counterbalanced by weights on the rod. This arrangement is automatic, and regulates the supply of air to the pump, and the pressure in the reservoir. If the pressure should still increase (by leak of receiving valve) the piston rises still higher, and lets the air escape, as in the ordinary safety valve.

Upon the deck of the vessel is situated the old fashioned hand steering gear, except that it has upon its drum a large friction wheel (36″ diameter), and under the system a grooved pinion, geared into the large wheel, which pinion is upon the shaft of, and is driven by, a pair of oscillating engines (4″ diameter of cylinder, and 5″ stroke of piston). These little engines are driven by the compressed air from the reservoir referred to above. They are reversed by a two-way cock, which changes the steam port into the exhaust, and vice versa, and which is actuated by a lever which is placed vertically in front of the system. The motions of the cylinders open and close their ports (proper) in the ordinary manner.

The drum, upon which the tiller ropes are coiled, moves upon an iron axis, which passes through, and has upon its ends, eccentrics. By turning this axial shaft, it is made to rise or lower, and thus the power gear is thrown in or out of contact. When out of gear, it is worked in the ordinary manner. When the main engines are at work, the air pump is moved by the shaft, and the steering gear is worked

by that source; but when the main engines are *not* at work, the propeller is uncoupled, and the line shaft is revolved by its propeller, which is in turn revolved by the pressure of the water upon the blades when the ship is under sail and making headway. It may be stated here, that screws revolve freely when the vessel is moving at three knots per hour. If, however, the vessel moves at a lower rate of speed, the weather is then fine, and one man may steer with ease.

In addition to the advantages already noticed, this gear is very elastic, as a blow upon the rudder would move the system backward, and compress the air upon the piston, offering a uniformly increased resistance. But when the resistance of the engines equaled the pressure on the rudder, and the strain was still considerable, the friction gear would slide over before it would break.

FLYING MACHINES AND PENAUD'S ARTIFICIAL BIRD.*

By ALFRED M. MAYER†, Professor in the Stevens Inst. of Techn'y.

(*Translated from the Journal de Physique.*)

Numerous attempts have been made at different times to construct a machine capable of propelling itself through the air. All kinds of aerial propellers have in turn been tried; such as screws, beating wings, umbrellas which open and shut during their reciprocating motion, inclined planes, aerial wheels. But though many of these projects called forth considerable inventive ability, yet, until quite recently, the *helicopteron*(from ἑλικός, anything spiral or twisted, and πτερόν, a wing—that is, a machine furnished with an aerial screw propeller) was the only type of machine which had succeeded in raising itself in flight. Several of these helicopterons have been constructed since 1784, at which date Bienvenu made the first that flew. The best known, and the most perfect, was that which Ponton d'Amécourt constructed in 1864, and which raised itself for a moment by a

* The Academy of Sciences of Paris, at its meeting in June, 1875, awarded to M. Pénaud a prize for the discoveries and inventions described in this article.

† Extracted by permission from *Popular Science Monthly*, Feb'y, 1876.

sudden motion to a height of two and a half meters. It was formed of two superposed right and left handed screws, put in motion by a watch spring. All other methods of artificial flight, including those of propellers with wings beating the air like those of a bird, remained ineffective, and were the subjects of conflicting hypotheses as to the nature of flight.

In beginning our studies, we have thought that the best means of getting rid of the multiplicity of hypotheses and of conflicting opinions would be to divide the flying machines that have been invented into a small number of general types; then to reduce each of these types to its essential elements, and finally to design a flying machine of each of these simplified types possessing all the really essential parts, and easy to construct.

Leaving out of consideration the inventions which are evidently defective, we have thought it possible to divide the majority of the systems of artificial flight into *helicopterons*, *areoplanes*, and *orthopterons* (from ὀρθός, straight, and πτερόν, a wing). The helicopterons sustain themselves by the aid of screws whose axes of rotation are nearly vertical. They may be made to progress either by these vertical screws or by special screw propellers. The areoplanes have propelling surfaces which are nearly plane and slightly inclined to the horizon. A horizontal motion is given to these surfaces generally by means of screws. Finally, in the orthopterons, the propelling organs are surfaces moving in vertical directions, and generally having reciprocating motions. In this system are embraced the wings of birds and the moving surfaces of the tails of fishes.

The knowledge of the resistance of the air appeared to us the only guide by which we could arrive at a thorough understanding of the manner in which a machine could sustain itself by the actions of its propelling surfaces on this fluid. We entered upon an attentive study of several imperfectly understood points appearing to us of capital importance; such as the sustaining screw, the aerial inclined plane, and the theory of the equilibrium of flying machines. The screw propeller was well understood from its effects in propelling vessels. These researches, which led us to a small number of very simple general laws, permitted us to determine the manner of action and the proportions of the machines which we desired to construct.

It remained to find a motor the easiest of application. Wood, whalebone, and steel, give forces which are at a minimum when re-

ferred to their weight; caoutchouc is much more powerful, but the framework necessary to resist its violent tension is necessarily quite heavy. We then conceived the idea of using the elasticity of the torsion of caoutchouc, which finally led to an easy, simple, and effective method of constructing the models of flying machines.

We applied the new motor first to the helicopteron, after having previously investigated the curious and valuable actions of caoutchouc when subjected to various successive torsions. In April, 1870, we presented models to M. de la Landelle, which rose in flight to more than fifteen meters, hovering and fluttering through large inclined circles, and sustaining themselves during more than twenty seconds.

The great superiority of these results over those obtained with preceding helicopterons encouraged us to apply our motor to other systems of artificial flight. On the 18th of August, 1871, in the presence of the Society of Aerial Navigation, we succeeded in making an areoplane fly with various velocities and in different directions, around one of the circles of the gardens of the Tuileries. The success of this machine in its ascending motions and in its perfect equilibrium gave the first successful exhibition of a machine on the areoplane type.

Measured directly, and irrespective of any hypothesis, the force required to sustain and propel the areoplane and the helicopteron proved to be relatively moderate, and did not approach the fabulous estimations previously given by Navier. This experiment demonstrated that the muscular strength of birds, although notably greater, for equal weights, than that of mammals, did not exceed a reasonable estimation.

Our helicopterons and areoplanes which performed with success on the 2d of July, 1875, before the Physical Society, have a numerous offspring. They have been imitated with various success by Crocé-Spinelli and MM. Montfallet, Pétard, and Tantin.

The action of these machines, in fully confirming our ideas and calculations on the resistance of the atmosphere, encouraged us to attempt the construction of a mechanical bird with flapping wings. The diversity of the hypotheses as to the nature of flight, proposed in France and in England, though bearing witness to the difficulties to be met with in the construction of this mechanism, yet rendered the problem peculiarly interesting.

The experiments heretofore made with mechanical birds had been very discouraging. M. Artingstall and M. Marey had alone obtained effective results. M. Artingstall states that, some thirty years since, he had an artificial bird which flew at the end of a tube jointed on to a steam boiler. M. Marey, whose beautiful physiological experiments are so well known, constructed, in 1870, artificial insects, which, attached to a radial tube carrying a counterpoise equal to two-thirds of their weight, rose and flew in a circle by the aid of their wings. The compressed air which set the wings in motion was conveyed to them through the radial tube from a compression pump worked by hand.* It remained to gain the two-thirds of the weight of the insect and to cause the latter to carry with it its motor instead of having the wings moved by a force conveyed to the insect from without.

Encompassed by the divers hypotheses of the action of the wing given by Borelli, Huber, Dutrochet, Strauss-Durckeim, Liais, Pettigrew, Marey, d'Esterno, De Lucy, Artingstall, etc., and in view of the very complicated motions they had assigned to that organ and to each of its quills—motions which are, for the most part, inimitable in a mechanical bird—we decided to reason out for ourselves, by relying on the laws of the resistance of the air and on some of the most simple facts of observation, what are *the motions of the wing really necessary to flight.* We found—1. *A double oscillation*, a depression, and an elevation of the wings transverse to the path of flight. 2. The change of the plane of the same during this double motion; the lower surface of the wing facing below and behind during its depression, so as to sustain the bird, the same surface of the wing facing below and in front during its elevation, so that the wing is raised with the least resistance by cutting the air with its edge while the bird flies. These movements, moreover, were admitted to be correct by a large number of observers, and have been concisely demonstrated by Strauss-Durckeim, Liais, and Marey.

But, in considering the difficulty of the construction of our mechanical bird, we were obliged, notwithstanding our desire to make a machine which should be simple and easy to understand, to try to perfect those actions we have somewhat summarily described. It is evident that the different parts of the wing, from its base to its ex-

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* *See* Fig. 87, on page 202 of Marey's "Animal Mechanism," published in the "International Scientific Series."

tremity, act on the air under very different conditions. The interior part of the wing, having small velocity, produces little propelling effect at any moment of its beat; but it is far from being useless, and one may imagine how, by presenting its lower face downward and slightly facing the front, it acts during the rapid translation of the bird, like a kite, as well while the wing is being elevated as during its downward motion, and thus sustaining in a continuous manner a portion of the weight of the bird. The middle portion of the wing has a junction intermediate between that of the interior and that of the outer portion, or end, of the wing; so that the wing, during its action, is twisted on itself in a continuous manner from its base to its extremity. The plane of the wing at its base varies but little during flight; the plane of the median part of the wing is very much displaced on one and the other side of its mean position; finally, the outer part of the wing, and especially its tip, experiences considerable change of plane. This warping of the wing is modified at each instant during its elevation and depression, in the manner just indicated; at the extreme points of its beat the wing is nearly plane. The action of the wing is thus seen to be intermediate between that of an inclined plane and that of a screw with a very long and continually variable pitch.

Notwithstanding the differences found to exist in the hypotheses of various authors when compared with one another and with the one just given, still one or the other of these writers confirms the greater portion of the ideas just advanced. Thus the torsion of the wing had already been pointed out by Dutrochet, and especially by Pettigrew, who long maintained this opinion; only he has taken, according to our view, the change of form occurring during the elevation of the wing for that of the form occurring during its depression, and *vice versa*. These authors clearly saw how the articulations of the bones, the ligaments of the wing, the imbrication and elasticity of the quills, bring about the above result. M. d'Esterno had explained the continuous effect, like that of a kite, of the interior portion of the wing during its depression and elevation; and M. Marey had very appropriately designated that portion of the wing as "passive," at the same time, however, maintaining that the most important action of the wing during flight is due to a general change of its plane produced by the rotation of the humerus on itself.

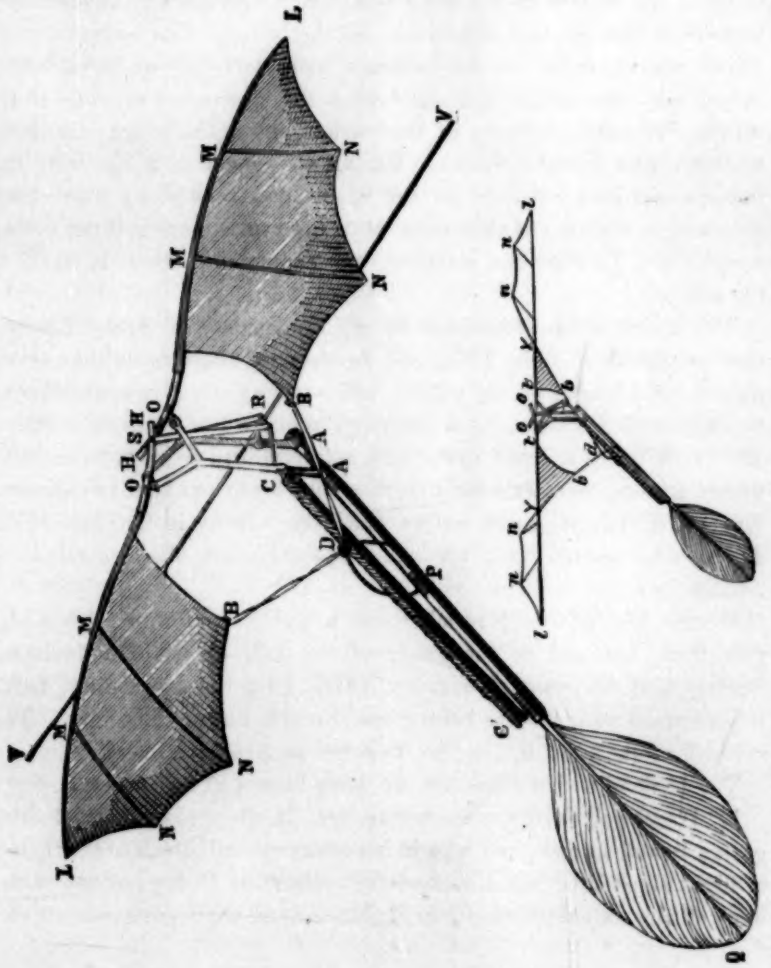
According to our view there is a sharp distinction to be made beween hovering and the ordinary flight of progression, while the am-

plitude of the changes in the plane of the extremity of the wing is essentially a function of the velocity of translation of the bird. At the extremity of the wing, where the most considerable changes of plane takes place, these changes equal 90°, and even more, during hovering; but then displacements of plane are far less in the flight of progression. According to our calculations the extreme portions of the surface of the terminal feathers of the crow's wing are, during free flight, inclined forward during the depression of the wing only from 7° to 11° below the horizontal, and from 15° to 20° above the horizontal plane during the elevation of the wing. The plane of the wing at its base acts during the above motions like a kite inclined at an angle only of from 2° to 4°.

It is easy to verify the slight inclination of the wing, and consequently the smallness of its angles of action in the air, by observing a flying bird moving in a horizontal line of sight, for we then see only the edges of the wings. It is, in short, inexact to say that the wing changes its *plane :* we can barely say that it changes its *planes.* The truth is, that it is gradually more and more warped in going from its base to its extremity. It was so understood, indeed, by an English author, whose labors we became acquainted with after we had constructed our bird, and to him we are indebted for having saved us several researches. The theory of Sir G. Cayley, published in 1810, differs from ours but in a few particulars. He is of the opinion that the outer portion of the wing in ascending exerts always a propulsive action, and he attributes to the propelling parts and to the sustaining, kite-like parts of the wing, proportions which are relatively the reverse of those to which we have been led by our calculation.

It was with these ideas, favorably judged of by the Academy in September, 1871, that we undertook the application of the torsion of caoutchouc to the problem of the mechanical bird. The wings of our bird are made to beat in the same plane by means of a crank and connecting rods. After several rough trials, we found out that the transformation of motion in the machine required a mechanism very solid relatively to its weight, and I requested M. Tobert, an able mechanist, to construct out of steel a piece of mechanism designed by my brother, E. Pénaud. The accompanying figure represents the apparatus so constructed; $C\,C'$ is the motor of twisted caoutchouc placed above the rigid rod, $P\,A\,A$, which is the vertebral column of

the machine; from this rod, at *A* and *A*, ascend two rigid forks, which serve below as supports for the crank, *C R*, which is attached to the twisted caoutchouc; and above, at the ends of the forks at *O* and *O*, are the pivots on which the wings oscillate. The links, *R S*, convert the motion of rotation of the crank into the reciprocating motion of the arms, *O M L*, *O M L*. At *Q* is a steering tail, which we found by experience was best made from one of the long feathers of a peacock's tail, and which can be inclined upward or downward, or to one side, and be loaded with wax so that the centre of gravity of the machine can be brought to the proper position.



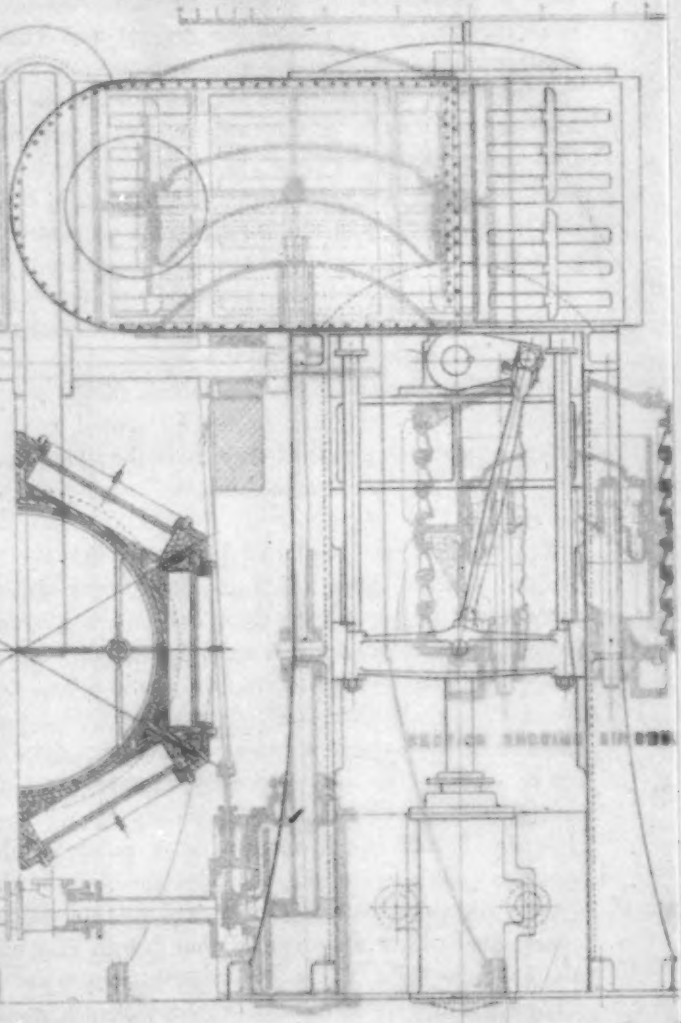
The warping of the wings, *O L*, is obtained by the mobility of the wing and of the little fingers, *M N*, supporting them on the large rods, *O M L*, which do not partake of this rotation. A little ligament of caoutchouc, *D B*, connects the posterior interior angles of the wings with the middle of the central rod of the machine. This ligament, whose function is similar to that of the posterior paws of the bat, plays the part of an elastic sheet to our wing, so closely resembling the topsail of a schooner. The torsions of the wing are thus automatically regulated, as required, by the combined action of the pressure of the air and of this elastic ligament. The interior third of the surface of the wing acts like a kite during the elevation as well as during the depression of the wing. The external two-thirds, corresponding to the primary and secondary quills of birds, propel and sustain the machine during the downward motions of its wings. The little drawing in the corner shows the wings just about to begin their downward beat. During the elevation of the wing the terminal feathers conform to the sinusoidal track along which they progress in the air; it thus only cuts the atmosphere without acting against it. To start the machine, we simply abandon it to itself in the air.

This machine was exhibited before the Society of Aerial Navigation on the 2d of June, 1872, and flew several times more than seven meters—the length of the public hall—raising itself in a continuous manner, with an accelerated velocity, along a line of flight inclined 15° to 20°. In an open space, the artificial bird flew over twelve to fifteen meters, elevating itself during this flight to about two meters. Another model, exhibited before the same society in October, 1874, flew in a horizontal line, vertically upward, and also ascended obliquely.

On the 27th of last November, at a public exhibition, this model flew from one end to the other of the hall of the Horticultural Society (*see Aéronaute*, February, 1875). On the 2d of July, 1875, it performed with success before the French Physical Society. The velocity of its flight is from five to seven meters per second.

The birds of twisted caoutchouc have been a great success.

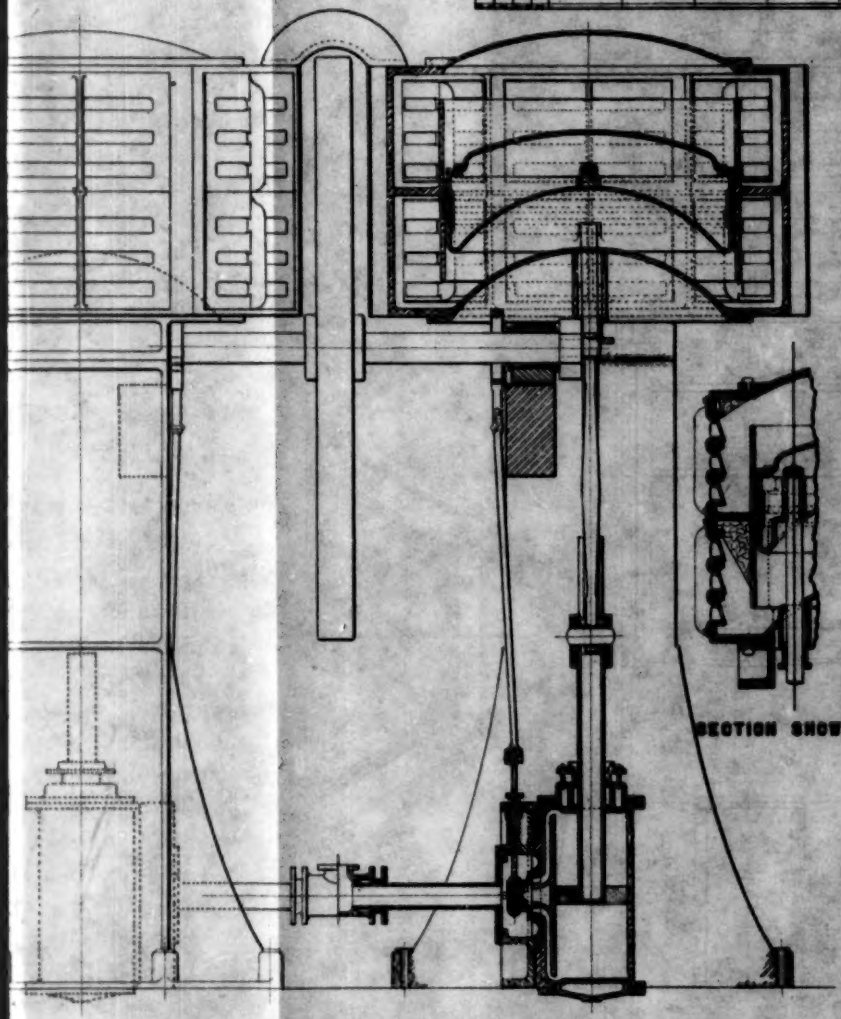
M. Hureau de Villeneuve, whose zeal in the study of aerial navigation is well known, and who in his many contributions to the theory of flight since 1868 has discussed the inclination to the horizon of the axes of the scapulo-humeral articulations and their posterior conver-


DOUBLE BLOWING
SIDE VIEW
TION AND HALF SECTION

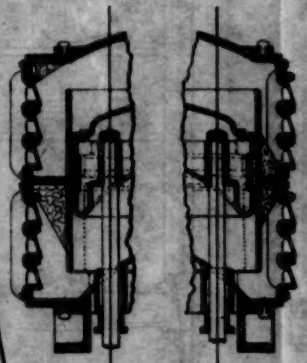
DOUBLE BLOWING ENGINE

DIA OF STEAM CYLINDER 28" – STROKE. 36"
DIA OF BLOWING CYLINDER. 48" – STROKE. 24"

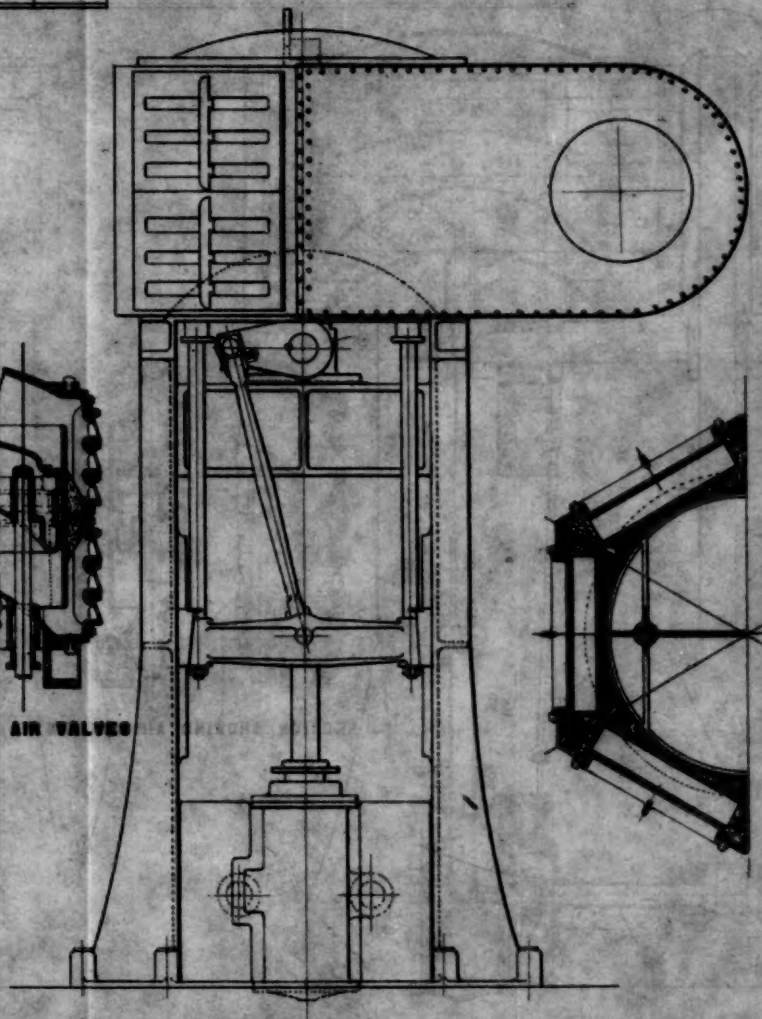
SCALE



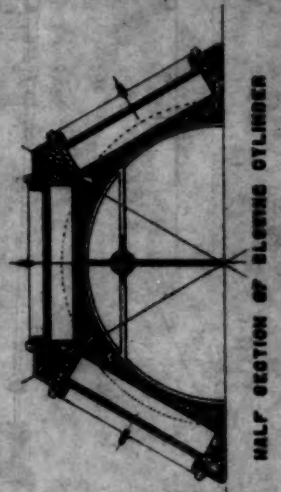
FRONT ELEVATION AND HALF SECTION



SECTION SHOWING AIR VALVES



SIDE VIEW



HALF SECTION OF BLOWING CYLINDER

Photo. Litho. & Printed by J.H. Camp 610 Jayne St. Phila'a

gence, exhibited, on the 20th of June, 1872, a bird moved by twisted caoutchouc, which, he states, elevated itself vertically to a height of nearly one meter. Continuing his researches with perseverance, he again exhibited his apparatus before the Society of Aerial Navigation on the 13th of January, 1875, after having supplied it with wings similar to those of my bird, and after having adopted several of the peculiarities which had made my machine successful. He then succeeded in giving sustained flight to his machine, which we have ourselves seen fly horizontally nearly seven meters, after having been started by a slight impulse from the hand. M. Tatin, also, in 1874, made two very curious artificial birds, using twisted caoutchouc as a motor. M. Marey has told us that he saw the first named fly in his garden, last November, from eight to ten meters. We have seen the second, nearly identical with our bird, fly in a still more satisfactory manner.

DOUBLE BLOWING ENGINE.

By Robert Briggs, Civil Engineer.

The engine shown on the accompanying plate was designed and constructed at the Southwark Foundry, of Philadelphia, 1873. It was put in use at the foundry for running one or both of two cupolas of the Mackenzie type, in substitution for two rotary pressure blowers of previous existence, which had been found somewhat inefficient in service, from original want of size and inadequate belt power. Probably so much elaboration would not have been expended upon the supply of blast to cupolas for iron founding, if it had not been determined to make the engine in every way suitable for the continuous service of cupolas at a Bessemer works, and also to exhibit the feasibility of extension of the system to blowing charcoal blast furnaces, or even to the larger (mineral) coal blast furnaces, used in the manufacture of iron from the ore. The result of the experiment, however, showed that the expenditure of money in the construction of these engines was amply warranted by the certainty of the action, the reduction of cost for wear of the machines or driving parts, and by the gain in expenditure for steam demanded to perform, more satisfactorily, more work than the pressure blowers formerly required, and as pressure blowers, when the requirement of blast is above a half pound per square inch,

were and are 15 to 20 per cent. more economical than centrifugal fans, the system of blowing by *tubs* would appear to be more profitable than any other. This last fact is generally admitted by all foundrymen where the quantity of iron to be poured daily, or at a time, is very considerable. The usual practice of direct steam blowing tubs has (in America at least) been a horizontal arrangement; in which the weight of the pistons, both steam and air, has occasioned a rapid impairment of the cylinders, demanding, commonly, a reboring of one or both after each two or three years' service. The attempt to support the piston of a horizontal cylinder (especially the air piston) by the piston rod, which in such cases is extended through the back head, has proved an utter failure, with or without the back cross head; and the common practice has been to run a horizontal blowing engine, with its leakages at the pistons, until the full pressure of steam available to drive the machine fails to give an adequate blast, when reparation becomes inevitable. The last portion of the time of running, therefore, is attended with great loss of effect and consequent increase of cost.

These conditions of wear attach also to the horizontal blowing engine for blast furnaces, which was, prior to 1848, in almost exclusive use in this country: our practice at that time having been a high pressure, direct acting one, in contradistinction to the beam engine of Smeaton or Watt, which formed and still forms the common type in Great Britain and on the continent. In 1847, the writer designed three arrangements of vertical blowing engines, with fly-wheel shaft below; one with tub above and cylinder below, and one head cross head and two fly wheels; the second with same disposition, but with intermediate cross head, and also with two fly wheels; and the third, with intermediate cross head, with cross tail, and one fly wheel. The third style of these engines was introduced by Mr. Wm. Firmstone, at the Glendon furnace, Easton, in 1848, and has continued in use to this time. Others like the first and second styles were built within two or three years of the same time by Messrs. I. P. Morris & Co., Port Richmond Iron Works, Philadelphia, (who also were builders of the engine for Glendon furnace). Since this time, this type of engine has met increasing favor, and it may now be said to predominate in American blast furnace use. The proportions of the first designed blowing cylinders were an equality of diameter with stroke, and until English practice had shown the superiority of stiffness of framing and in steadiness of work, proceeding from a shorter stroke, these

proportions were followed; but more recently, within the past four or five years numerous short stroke (*i. e.*, a little less than two of stroke to one of diameter) engines have been built and put in operation. The writer is of opinion that there were vertical engines in the neighborhood of Liege, Belgium, built prior to 1847, but upon this point he is not positively informed. It is certain that there was a vertical engine without fly wheel at Seraing prior to 1851, as described by Valerius.*

Returning to the consideration of the engine at the Southwark foundry, it will be noticed that the arrangement of inlet and outlet valves was taken from the practice of John Gjers,† but in other respects the disposition of the several parts of the machine is thought to be different from any previously proposed. It will be seen from the plate that the arrangement consists of two separate vertical engines, connected to one shaft with a single fly wheel. In each of the engines, the steam cylinder casting was placed between two upright side frames, joining them together at the bottom, and the lower head of the blowing tub rested upon, and was attached to, the top of these frames. A wide cross head received the piston rod of the steam piston in its centre, and the two piston rods of the blowing piston were joined to cross head at such distances apart as would allow the crank to rotate between them. The bottom head of the blowing tub was hollowed upwards to allow the crank to pass over its upper centre, and bring down the entire height of the engine to the least practical limit. These two engines were in every respect independent from each other, except the coupling by the same shaft, and except also a small yoke or bridge over the fly wheel, which will be noticed on the plate. The last, however, was not essential in working, but only convenient in construction and especially in erection. A foundation of brickwork, consisting of two 18 inch (2 brick) walls of 3 ft. depth (to solid original ground), and about 8½ ft. each in length, served to carry the engines and for the securing of the foundation bolts. For the maintenance of stability of the double engine when at work, even this foundation was uncalled for, nor was the yoke connecting piece necessary, for it was found upon trial in the erecting shop of the Southwark foundry, where it stood, not fastened to a plank floor, upon stake wedges and

* Fabrication de la fonte, Brussels, 1851.

† See JOURNAL OF THE FRANKLIN INSTITUTE, present volume, page 19.

leveling shims of iron; that the speed of 110 revolutions per minute was attainable without vibration of moment, and without apparent tendency to move from its loose supports. The steam required to produce this rate of motion was supplied by a two in. wrought iron pipe about 100 feet in length, through numerous elbows, from a boiler carrying 45 to 60 lbs. per square inch, and the air escaping from the cylinder gave about $\frac{3}{4}$ to 1 lb. per square inch. The subsequent use of the engine when in work at 60 to 70 strokes per minute, with 0·8 lbs. pressure, exhibited the same freedom from disturbance and exemption from vibratory movement.

The steam cylinders of this double engine were 12 inches diameter by 24 inches stroke, with a solid piston and three Ramsbottom rings of 5-16 square steel for packing. The result of service in these packings has been to show a duration in continuous daily use, accompanied with unexceptionable tightness, of about 18 to 24 months; or in such cases as this one, where the use was about four hours per day, about twice as long time. The plain slide valves had a broad lap to cut off at $\frac{5}{8}$ the stroke, with a good *negative* lead and ample cover to the exhaust, *ensuring* quiet rotation, notwithstanding the expenditure of the expansive force of the air in the tub upon the crank, which occurs after passing the centres and before the entrance of air into the tubs on the return strokes. The steam piston *rods* were made of a common $4\frac{1}{2}$ in. wrought iron tube, $\frac{1}{4}$ of an inch in thickness, which was screwed into the piston with a taper thread upon the *rod* of 1 to 32 on each side, the thread being a V of $\frac{1}{8}$ an inch pitch. The lower or bottom end of the rods (tubes) had a head welded in, and the upper end covers to keep out dirt. These dimensions of piston rods gave an approximate balance of steam pressure on the under side of the pistons against the weight of the reciprocating parts—both the pistons with all rods, the cross heads, connections and cranks—so that with the coupling of the pair of engines at right angles, no balancing on the fly wheels or by crank balances was required. The cross heads were cast iron, of considerable depth but of great lightness.

The blowing cylinders were 48 inches diameter by 24 inches stroke, with hollow cast iron pistons, having cast iron covers, or followers, as they might be called. The packing rings were two of Ramsbottom's, of cast iron, 2 inches by $\frac{1}{2}$ an inch section, held out by leather backing strips placed behind them in the grooves, the leather being $1\frac{7}{8}$ inches wide to allow the elasticity of form to be brought into

action. The blowing tubs seemed to work with tightness for two years of service, but no examination was made to see what wear had occurred at that time. The valve arrangement, as has been stated, was borrowed from Mr. Gjers, but it was evident that the area was much in excess of the necessities of supply or delivery of air. The motion of the valves on the supply side was exceedingly small as a whole, but a singular distribution of wide opening took place at the fullest speeds. Out of the nine inlet valves on one end of one cylinder, not over five or six would move perceptibly (except on close inspection), while 1, 2 or 3 would open quite wide, but it would not be the same one or more on the next stroke; on the contrary, a valve which did not lift at all on one stroke might move next time to a wide opening. The conclusion apparent seemed to be that while the whole periphery of a blowing cylinder might be needed for the valves of cylinders of eight feet stroke, two-thirds of that periphery would suffice with the four foot example here given. Double leather valves of the sizes assumed, proved too stiff and refused to close tight, so that the air delivery became insufficient and a very high temperature of air in the cylinder resulted. Single leather valves with additional cross bars overcame all difficulties, and repeated examination showed that the valves closed with tightness, and opened without resistance. No sign of wear of the leather valves was exhibited after nearly two years' service. Prepared black lead with a small amount of sperm oil was the occasional lubricant of the blowing cylinders. The valves were well filled with dubbing at starting, and did not harden.

A governor working a throttle valve was attached to the engines at first; the Huntoon governor, which possessed the nominal advantage of possible alteration of rate of speed while running, was tried, but it was found that the engines run irregularly with pulsations of 10 or 15 strokes of length in accelerating and retarding velocities. The governor was then removed, and it appeared that the labor of the engine increased so rapidly with the quantity of air delivered (the pressure augmenting) that there could be no fear of its running away from any practical cause, and the speed thereafter was controlled with the main steam valve by the attendant of the cupolas.

As a matter of some interest, the loss of performance (not efficiency) arising from the clearance in the air cylinder, was investigated. Owing to the difficulties of measurement of the corners, the valve boxes or mouths were filled with water (after the wooden filling pieces for waste spaces were in) from a weighed vessel.

Weight of water in one partition of inlet in *cubic feet*,	.	0·98	
Measurement of remainder of same partition	" .	0·57	
Weight of water in one partition of outlet	" .	0·56	
Measurement of remainder of same partition	" .	0·54	2·45
For three partitions . . .	" .		7·35
Add a half inch clearance of piston,	" .		0·52
Total clearances at each end of cylinder,	" .		7·87

As the area of the cylinder equals 12·56 sq. feet, the displacement of a stroke equals 25·12 cubic feet, and it follows that these clearances of 7·87 cubic feet are equivalent to 5-16ths (0·3125) the displacement of the piston, or 7½ inches of the length of the stroke. Assume:

Pressure of blast at lbs. per square inch,

1 2 5 10 15 20 25

Then the total pressure upon the air enclosed in the clearances becomes in each case equal to these plus 14·7 lbs., and the 7½ inches upon the area of the piston will expand before the atmospheric pressure is reached, and the inlet valves can begin to open

1	2	5	10	15	20	25
14·7	14·7	14·7	14·7	14·7	14·7	14·7

or in inches of length of stroke,

0·51 1·02 2·55 5·10 7·65 10·2 12·75

and, in place of 24 inches or the whole stroke, the effective length of stroke becomes, *in inches of length of stroke,*

23·49 22·98 21·45 18·90 16·35 13·80 11·25

and the volume of air at atmospheric pressure, taken into the air cylinders at each double stroke of the pair of engines, becomes, *in cubic feet per revolution of fly wheel,*

98·21 96·14 89·66 79·00 68·34 57·68 45·02

as the total displacement of the air pistons would be 100·48 cubic feet, the proportion of performance to displacement will be easily seen to be almost in decimals as given in the last line of figures.

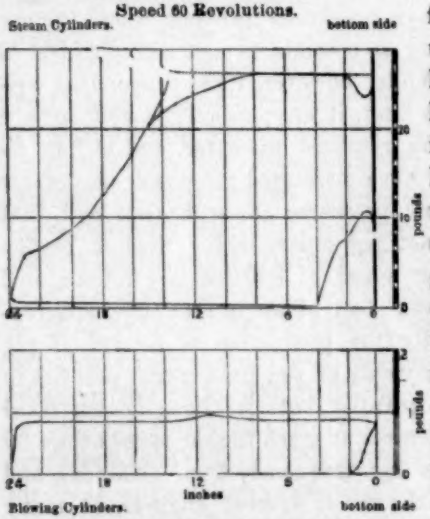
There is, of course, no loss of useful effect in this loss of performance or capacity, except what proceeds from friction of parts of the engine as a whole, (or in possibly some complicated phenomena of transformation of force to heat); for the same force which is expended in the compression of the volume of air left at the end of the stroke in the clearances (which it has been shown equals 7½ inches of stroke) is given back in impulse to the engine by expansion on the return stroke. Of course, this statement overlooks the resistance of the valves and the leakages, for which it may be presumed a fur

ther allowance of 5 to 10 per cent. of the capacity of the air cylinder as a whole can be admitted as loss in actual performance. Whence it would appear that with 25 lbs. pressure of air blast (above the atmosphere), blowing engines with valves, valve spaces and total clearances, as shown in this example, would deliver less than half the quantity of air due to the displacement of the air pistons, while at 2 lbs. pressure, they would deliver about nine-tenths of the same displacement. If the supposed blowing engine to give 25 lbs. were to have (as appeared from observation of this example to be sufficient) but two-thirds the number of valves, and the valve passages be proportionally reduced in size; the ratio of delivery to displacement would thus (under 25 lbs. pressure) be increased from 45 to 56 per cent. This supposition of 25 lbs. pressure requirement is obviously in great excess, and at the practical pressure for a blast furnace of 10 lbs., the air delivery of these blowing engines approximates towards 80 per cent. of the capacity of the air cylinders.

INDICATOR DIAGRAMS.

DOUBLE BLOWING ENGINE.

Speed 60 Revolutions.



The accompanying pair of diagrams will illustrate the performance of the engine on regular work in the middle of a heat (of three or three and a half hours) before the charge in the cupola had become very heavy. At the time of taking these cards, the pressure of steam, as given by a pressure gauge at the boilers, one hundred feet distant from the blowing engine, was 56 lbs., and at the water separating reservoir (6 feet long of 12-in. vertical pipe), about twelve feet from the engine, at least 48 to 50 lbs.; and it was consequently necessary to throttle the steam by the main steam valve to give the 26 lbs. maximum steam pressure indicated on the cards. As no considerable steam supply chamber existed in the pipes and steam chests between the main valve and the slide valve faces, the effect of the throttling upon the top line of the indication, when both cylinders were receiving steam simultaneously, is marked. The steam pressure will be seen to

have equaled 17·8 lbs. on the average, and the air pressure 0·8 lbs., giving the entire useful effect of the steam of 72 per cent. to the passage of the delivery valves, all frictions of engine being included. This ratio of useful effect would increase with an increase of pressures. At and below a half pound pressure per square inch, the centrifugal fan becomes the more economic machine, the ratios of economy of the fan over any other means of moving air increasing rapidly as the pressures fall below twelve inches of water column; above this pressure the rivalry is between the reciprocating and the rotary engine, and at the present time the rotary engine, either as a motor or as an appliance of force, seems scarcely to have equaled the reciprocating one.

The proportions of the steam to the blowing cylinder, one to sixteen, in this instance gave the definite ultimatum to the pressures. The steam was supplied by a four inch pipe of about 100 feet length, but well coated for protection from loss of heat, from boilers usually carrying 60 lbs. pressure; some other demands were supplied by the same pipe, so that the final supply at the engine could not be taken to exceed 48 to 50 lbs. pressure, and with the cut off and cushion of the valve, the average maximum pressure would become about 40 to 45 lbs., thus giving a possible pressure of air blast of from 2¼ to 2½ pounds only. While, however, these proportions controlled pressure of blast to this limit, it was perfectly feasible to have made the steam cylinders of any required diameter, and at 2 ft. diameter this little engine would have possessed the power needed for running a blast furnace at usual pressures for anthracite coal, that is, up to 10 lbs. pressure of blast per square inch. Such an engine running at the moderate piston speed of 320 feet per minute, or 8 revolutions, would give 7000 cubic feet of air in that time, and represents the average demand for the production of 30 tons of pig metal in 24 hours. The requirements of the most recent practice in iron making are much larger in quantity, but it has been demonstrated that these engines run with quietness at much higher speeds than 80 revolutions (120 revolutions having frequently been attained), and there can be no objection to the use of several engines, as many may be desired to supply a quantity demanded, while there are many advantages which would follow such use. For the cupola, or for the light blast of the light burden of a charcoal furnace, the type of engine now described offers, in simplicity of construction, in steadiness of blast, in probable duration and exemption from accident, in room occupied, and in original cost, many palpable advantages.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxxi, page 126.]

The calculations which Helmholtz‡ has lately put forward, concerning the respective ratio of bulk to resistance and to speed in ships and balloons, are, therefore, of great value. According to him, the speed of Dupuy's balloon nearly attained the maximum possible for its size. In order to proceed slowly against a fresh breeze, with the sources of mechanical power at present available, the volume of the balloon must be three and a half times larger than that of the largest ship of the line. This demands of the tissue with which the balloon is to be constructed, a degree of strength scarcely possible. In fact, the expectations of the inventors did not go beyond the hope of steering the balloon when the air is tranquil. If the screws and paddle wheels are enlarged, they must also be made thicker or stronger in order to preserve the necessary firmness. "We can only work sparingly with slow-moving propellers of large surface, and to produce these of the requisite size without burdening the balloon too much, will constitute one of the greatest practical difficulties."

With this sentence, Helmholtz concludes his memoir, and the prospects to which he points fall very far short of the enthusiastic prophecies of such as are guided by their wishes rather than by sober scientific considerations.

The problem of steering balloons turns on three conditions—the

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* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News*.

‡ Helmholtz, *Berl. Akad. Ber.*, 1873, 501.

production of balloons of the lowest specific gravity; the construction of propellers, light, but capable of resistance; and of sources of power at once light and capable of performing a high duty. In how far chemistry has prepared the way towards the fulfillment of the last condition, *e. g.*, by means of aluminium, the future must decide. The first condition she has accomplished ninety years ago, by means of hydrogen, as is now fully recognized.

[On the evidence of these documents the procedures for illumination with hydrogen hitherto employed must be condemned, if anything further is desired than the display of objects and transparencies for the lecture room or the stage.

Hydrogen lighting was not represented at the Vienna Exhibition —a further indirect evidence that it had not found any wider application.

An objection, long known, depends on the high coefficient of diffusion of hydrogen, and its consequent ready escape through the pores and fine chinks of the mains, a circumstance the more dangerous, as hydrogen is not, like coal-gas, at once detected by its odor. The diffusion coefficients of gases, according to Graham's experiments, are inversely as the square roots of their specific gravities.

But if lightness is a disadvantage for the delivery of hydrogen through pipes, we have now to consider the advantages springing from the same attribute. In November, 1872, a dream long cherished seemed on the point of fulfillment. The brothers Etienne and Joseph Montgolfier sent up the first balloon at Avignon by means of hot air.*

With natural enthusiasm the populace of Annonay applauded them when, on June 4, they repeated the experiment of the previous year on a larger scale, and king, court, and capital congratulated the inventors when they repeated it soon afterwards at Versailles. The dominion of the air seemed won for mankind, to whom space had now no limits. To-day we look back upon the invention with a cooler glance, as, in spite of the lapse of ninety years, it has remained in its infancy. We are still unable to speak of aerial navigation, since the balloon, incapable of being steered, has remained the plaything of the air instead of becoming its ruler. One step, indeed, towards

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* The historical details concerning aeronautics, where no other authorities are given, are taken from the excellent summary of Louis Figuier in *Merveilles de la Science*, ii, 426–626. See also Marion, "Les Ballons," Paris, 1867; and Fonvielle, "La Science en Ballon," Paris, 1869.

the desired end was taken when Charles, Professor of Physics at the Conservatoire des Arts et Métiers, at Paris, substituted hydrogen for the heated air in the balloon. On August 27, 1783, Charles, in concert with the Brothers Robert, skillful mechanicians, accomplished the ascent of the first hydrogen balloon in the Champs-Elysées, his invention being known as the Charliere in contradistinction to the Montgolfiere. Both systems were used for the first aerial voyage, the one in November, and the other in December, of the same year. Previously, the balloons had been sent up empty, or only tenanted by some animal. The first aerial navigator, Pilâtre de Rozieres, conceived the idea of combining both systems, which was the occasion of his death. The fire in the Mongolfiere was communicated to the hydrogen in the Charliere, and on June 15, 1785, balloon and aeronaut fell shattered on the limestone rocks of the coast, near Boulogne.

The motive for this unfortunate combination was the wish to raise or lower the balloon by stirring up or extinguishing the fire—a plan which makes ballast superfluous, and which has been revived in a recent essay* by Captain Gaede (of the Military School at Hanover), and with due precautions would be doubtless practicable. Since the time of Pilâtre de Rozieres, 3700 balloon ascents have been undertaken, and only sixteen fatal accidents have been heard of,† due chiefly to Montgolfieres, though the sea has been repeatedly crossed by aeronauts. Not long after the discovery of balloons, they were used both for practical and for scientific purposes. Coutelle used them for military reconnoitering, and according to Carnot's testimony, contributed essentially to the result of the battle of Fleurus. On the other hand, Captain Gaede considers the results attained by means of balloons, especially in reconnoitering fortified places, both in earlier campaigns and in the Franco–Prussian war of 1870–71, as insignificant. Napoleon I. regarded the military efficiency of the balloons of his time not more favorably. After his return from Egypt—where the attempt to convince the natives of the superiority of Europeans by means of a balloon ascent had failed, owing to their fatalistic indolence—he closed the military aerostatic school which

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*Gaede, "Ueber den Bau Gefesselter und Lenkbarer Luftschiffe." Berlin: Mittler, 1873.

†Stephan, "Weltpost und Luftschiffahrt. Berlin: 1874.

had been founded at Meudon, under the management of Coutelle and Conti, evidently holding its military results as unimportant.]*

Upon the consideration of hydrogen and oxygen should follow an account of the industrial applications of water. These, however, are so many-sided—not to say omnipresent—that they escape our reach. The most important will be considered in special chapters.

The elements, oxygen and hydrogen, form, however, as is well known, a second compound, peroxide of hydrogen, H_2O_2, which has latterly begun to acquire a certain industrial importance.

Peroxide of Hydrogen.

In 1818, Thénard caused acids to react upon barium peroxide, and obtained solutions extremely rich in oxygen, which they gave up with remarkable ease. He considered them as higher grades of oxidation of the acids employed, but soon perceived their true nature.

His method of preparation, which is still in use, is as follows: A known amount of concentrated hydrochloric acid is diluted in a beaker with 8 to 10 volumes of water, and exposed to a freezing mixture. A quantity of barium peroxide, somewhat less than sufficient to neutralize the acid, and as free as possible from other oxides (especially from manganic oxide, which would decrease the yield), is ground up to a fine pulp with water, and gradually added to the acid, in which it should dissolve without effervescence. Dilute sulphuric acid is then cautiously added, in order to throw down the dissolved baryta as sulphate and liberate hydrochloric acid, which then serves to react upon a further quantity of baric peroxide. After the liquid has been filtered off from the barium sulphate, a new dose of pulpy barium peroxide is added, and the above described process is several times repeated. After the sixth or seventh addition, the liquid contains a sufficient amount of the peroxide of hydrogen. If perfect freedom from acids is required, it is successively treated with sulphate of silver and hydrate of barium. The filtrate is concentrated over sulphuric acid in a vacuum.

Pelouze adds a paste of barium peroxide to a solution of hydrofluosilicic acid, and filters the solution of peroxide of hydrogen from the fluosilicate of barium.

Dupré† and Balard use a solution of carbonic acid in water for the

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* Erratum.—That portion of this paper which is included by brackets should have been printed in the article, page 123, following "Society," and before "Ballooning."

† Dupré, *Comptes Rendus*, lv, 736 and 758.

same purpose, adding gradually very small quantities of finely pulverized peroxide of barium.

Recently J. Thomsen has proposed the following modification of Thénard's process* :—Finely ground peroxide of barium, or the commercial so-called hydrate, is dissolved by addition to dilute hydrochloric acid, till the latter is almost neutralized. To the filtered and cooled solution so much baryta-water is then added, that foreign oxides and silica are thrown down, and a slight precipitate of barium peroxide is formed. The solution is then filtered and mixed with a sufficient quantity of concentrated baryta-water, whereby, as was shown by Brodie,† crystalline hydrated peroxide of barium is deposited. The precipitate is filtered and washed till it no longer shows the reaction of hydrochloric acid. The hydrate thus obtained can be preserved for a long time in closed vessels in the moist state. To obtain peroxide of hydrogen it is added, with stirring, to dilute sulphuric acid. The concentration of the latter may reach 1 part of acid in 5 parts of water. When the solution shows only a very faint acid reaction the sulphate of baryta is allowed to settle and the liquid is filtered.

(To be continued.)

VARIETIES OF THE SUGAR CANE.

Mr. H. Prestoe, the colonial botanist of Trinidad, has recently published an official report, describing the fourteen best varieties of sugar cane, among thirty-two surviving kinds of a larger number sent from the Mauritius, and stating the conditions (twenty-five cents for a stout plant or tuft, or in joints at twenty-five cents for every five), at which planters can obtain any of those that are ready for cutting and planting. Eighteen of the thirty-two seem to be distinct varieties, and deserving of care and cultivation, as possessing characters that give them, in one way or other, a superiority over the two or three sorts at present in cultivation, and among which the yellow Otaheite takes by far the largest place. Some of the new varieties are peculiar for length of joint (properly *internode,* or 'tween joints), and some for length of joint united with stoutness. One is remarkable for both, joined with a very soft tissue. This sort is of a fine, dark, claret color, and is numbered 10 in the list. In common with many of the others, it

* Thomsen, *Ber. Chem. Ges.*, 7, 74.

† *Pog. Ann.*, cxxi, 372.

also bears drought well and is prolific. Two (Nos. 13 and 14), being extremely hardy and prolific, are recommended as fodder canes, to plant on poor, dry soils, unsuited for the better canes. They are much hardier than Guinea grass, and will yield a manifold greater weight per acre of surpassingly nutritious fodder. They are purple-striped. No. 8 much resembles the best yellow Otaheite. No. 11, a dark purple cane, perhaps a less luxurious offshoot of same parent as No. 10, is also soft in tissue. All to No. 12 are described as stouter, more promising canes than the Otaheite, planted in the same soil at the Garden, and under the same conditions, and which were rarely 1½ inches in diameter. Only No. 4 was so small, Nos. 2, 6, 9, 11, and 12 being 1¾ inches, Nos. 1, 3, 5, and 7 being 2 inches, while the joints of the very handsome, clean cane, No. 10, averaged 2½ inches in diameter by 6½ inches long. No. 5 has 6 inch joints, No. 9, 5½ inches, and Nos. 4, 6, 11, and 12 have 5 inch joints. Those of No. 1 are 4½ inches, of No. 3, 4 inches, and of Nos. 2 and 7, 3½ inches. The joints of Nos. 8, 13, and 14 are undescribed. No. 6 grows very straight canes. No. 7 retained a green foliage, and although short in joint, is stated to have a very fine habit. The botanist is careful to say that, having grown on poor soil, the dimensions given indicate not the ultimate standard these varieties will attain to under more favorable conditions, but only their relative value compared with the common Otaheite, in fields planted alongside of them. He anticipates that a richer and moister soil will improve all. Purple and purple-striped canes are generally admitted to be preferentially adapted, by the hardiness of their habit, to the poorer, drier soils; but, it must be remembered, they have a hardness of tissue that gives more trouble in crushing. Nos. 10 and 11, however, are remarkable exceptions, and he thinks that others of the list, when tried in really good soil, will improve, and assume a freer habit, and gain a larger size than ever shown by our old friend, the yellow Otaheite. There are green canes in the Botanic Garden, possessing characters thought peculiar to purple canes. The paper mentions incidentally a grand purple cane obtained from the islands of the South Western Pacific, the "Queen" cane, whose joints are 4 or 5 inches in diameter. It will take a few years to establish a good supply of any favorite variety. Experiments in shortness of time to ripen, gallons of liquor per acre, saccharine strength per polariscope, and other particulars are also required before the planter can know the relative value of the different

kinds. There is not the least reason to doubt that with selection and good nursing, very superior and fixed qualities can be obtained in sugar cane, as freely as they have been in wheat, turnips, beet, fruit, garden flowers, and domestic stock. Tropical staples are ages behind Europe in this respect, and have hence grand possibilities *in ovo*, but they will not be realized without effort, judgment, and perseverance. According to the *West Indian*, a Barbadoes paper, a foot in length of sugar cane grown in that island weighs ¾ of a pound, and a bunch of canes grown in one hole weighs 54 pounds on an average, which yield 4 gallons of liquor or juice, from which 4 pounds of muscovado sugar are got. Of the 54 pounds, the juice weighs 50 pounds. An acre of ripe canes, planted six by five feet, gives 1452 bunches, or 5808 gallons of juice, or 5808 pounds of sugar. At 50 pounds of cane to the hole (or hill) an acre of canes, planted as above, would weigh, when cut, 72,600 pounds, or 36 tons, 90 per cent. being juice. It takes these 36 tons of cane to give 2½ tons of raw sugar, or 360 tons, from a 10 acre field, to yield 25 tons of sugar. For the first six months the plant requires but little rain to keep it in vigor; but afterwards in needs a constant supply and an increase of growth in the last three months of the year.

ANALYSIS OF "TELL-TALE SUGAR LIQUOR" FROM THE SAFES OF TWO VACUUM SUGAR PANS.

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All vacuum sugar pans (exceptional instances overlooked) are furnished with "tell-tale sugar liquor" safes for catching any "sugar liquor," etc., which might accidentally or peradventure "otherwise" boil over during the evaporating process in sugar refining.

These safes yield, when emptied, solutions which may vary in chemical composition according to a great variety of circumstances. First of all, the mechanical construction of the pans may have a great deal to do with this, as has also the position in which the safe itself is fixed. If the pan is low set and very short in the swan's neck, ten to one but that the "liquor" drawn from the safe of such